MODELLING SATISFACTION FOR MAIN PARTICIPANTS OF THE CONSTRUCTION PROJECT COALITION: A STUDY OF MUTUAL PERFORMANCE ASSESSMENT

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Abstract

In the context of the construction project coalition (PC), the satisfaction of each participant is essential to harmonious working relationships which, in turn, is pre-requisite to improved project performance and successful project implementation. Therefore, there is a need to investigate mutual performance assessment between main participants of the PC, i.e. clients, architects and contractors. The principal aim of the research was to develop models of satisfaction for each participant based on a framework of mutual performance assessment. These allowed the interrelationships between participant performance and the satisfaction levels of other participants to be examined, leading towards developing a better understanding of the determinants of satisfaction.

The development of the models involved performance and satisfaction attributes as independent variables and levels of satisfaction as dependent variables. Data were collected via a UK-wide questionnaire survey of clients, architects and contractors. Performance attributes represent characteristics of the performer that may influence satisfaction levels of the assessor. Satisfaction attributes represent characteristics of the assessor that may influence their own satisfaction judgements. The use of a singular or multiple measures of satisfaction levels was thoroughly considered. Subsequent analyses led to the decision to use a single measure of satisfaction, that is overall satisfaction (*totsat*) derived from one question in the questionnaire.

Models of satisfaction were developed for each participant using both multiple regression (MR) and artificial neural network (ANN) techniques. While the MR technique was chosen because of its ability to predict levels of satisfaction, the ANN technique was applied because of the nature of the research problem which suggested that a somewhat more 'sophisticated' tool was needed. The reliability and robustness of the models were tested and confirmed using independent (hold-back) data, i.e. that which had not been used to develop / train the models.

The models suggest that a capable client's representative and project architect are essential for higher levels of satisfaction. Therefore, the selection of these figureheads must be carefully considered. Additionally, the appointment of a contractor with an excellent track record is also crucial for enhanced satisfaction levels. Most importantly, clients must give considerable thought to the method of procurement. Here, it is suggested that long-term relationship-based procurement routes, such as partnering and strategic alliances may have advantages over traditional competitive tendering routes. A comparison of the models revealed that the ANN and MR models tended to highlight different variables, and that in terms of accuracy and consistency, the ANN models were marginally better than the MR models. For reasons of practicality, the MR models may therefore be preferred. In sum, the models developed could be used to predict satisfaction levels and to help improve performance and enhance levels of satisfaction. This ultimately will help to create a performance-enhancing environment leading to harmonious working relationships between project coalition participants, and so encourage continuous performance improvement for the betterment of all involved.

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Definition of Terms

Attributes

A set of characteristics or nature or other phenomena, typically measurable, that impact performance assessment.

Performance attributes

A set of characteristics representing the nature of a particular participant or a project which affect participant's actual performance. Performance attributes are categorised into two sorts, participant and project. Participant attributes directly affect participant performance and are inherent within the participant's organisation, team or individual for a particular project. Project attributes indirectly affect performance and are inherent within the project. In other words, project attributes define the characteristics / nature of the project, representing the 'environment' in which the participants must perform.

Satisfaction attributes

A set of characteristics representing the nature of a particular assessor (i.e. respondent) which form a frame of reference that affects their judgement in the performance assessment (i.e. satisfaction judgement). Satisfaction attributes are divided into two categories, i.e. assessor attributes and assessor's employer attributes. Assessor attributes are inherent within the assessor and include respondent's perception of the other participants' performance. Assessor's employer attributes are inherent within the respondents' company.

Construction project coalition

The construction project organisation consisting of separate participating organisations with different individual interests, which come together on a temporary basis to meet the needs of clients and those of their own (Winch, 1989; Winch and Campagnac, 1995).

Frame of reference

The internal standard (or standards) a person uses in making an evaluation. Different persons enter the same objective situation with different frames of reference, which affect both their summary evaluation of the situation and the aspects of that situation which are pertinent to their judgements. This standard is related to their prior experience, their predilection for making a given response, their expectations, and their threshold for change in a given stimulus dimension (Smith *et al.*, 1969).

Performance assessment

An assessment (e.g. made by a particular participant) of performance (e.g. of the other two participants). The assessment determines the levels of satisfaction of that (assessing) participant towards the performance of others. This assessment embraces objective and subjective performance assessment. While objective performance assessment involves performance attributes, subjective performance assessment involves satisfaction attributes.

Performance assessment case

A case of performance assessment represents one participant's assessment of another participant, e.g. clients' assessment of contractor performance. In this research, since there are three participants to be considered (i.e. client, architect and contractor), there are six performance assessment cases.

Performance criteria

A set of criteria used to measure the performance of a particular participant in the performance assessment. These criteria can be used to measure the performance exhibited by that participant throughout the (e.g.) life of a project.

Performance and satisfaction (interaction)

This concerns the interrelationships between participants in the context of the construction project coalition. Performance and satisfaction are considered significant to overall project performance. A participant exhibits performance and feels satisfied / dissatisfied with the performance of others. This interrelationship is mutual between participants.

Satisfaction dimension(s) or dimension(s) of satisfaction

Aspect(s) of satisfaction based on the performance of other participant. Dimension(s) of satisfaction are claimed to be a property of human experience and thought (Swan and Combs, 1976), that is inherent within an individual's mind. In this research, the principal components analysis (PCA) was utilized to identify dimensions of satisfaction, based on the scores attributed to the performance criteria of a particular performance assessment case.

Satisfaction Measure(s)

Measure(s) related to levels of satisfaction. Satisfaction measure(s) could be considered as a singular or multiple concepts depending on the result of the data analysis. That is, where multiple measures are used, these should demonstrate some distinction between each other to demonstrate that they are in fact measuring different aspects of satisfaction. If this is the case, several satisfaction measures were derived from several dimensions of satisfaction (a satisfaction measure was produced by averaging the satisfaction scores attributed to the performance criteria within one dimension of satisfaction). Otherwise, the use of a single measure such as the overall satisfaction (*totsat*) which is derived from one question in the questionnaire. The validity and reliability of these measures should be tested and before their use as dependent variables in the models.

Chapter 1

Introduction

1.1 OVERVIEW

The construction project coalition, defined as the construction project organisation consisting of separate participating organisations with different individual interests, which come together on a temporary basis to meet the needs of clients and those of their own (Winch, 1989; Winch and Campagnac, 1995), is a unique organisation. This uniqueness is mainly characterised by *disintegration* (i.e. separation of product design and production process) (Nam and Tatum, 1992; Puddicombe, 1997), *temporariness of the organisation* (Cherns and Bryant, 1984; Reve and Levitt, 1984; Mohsini, 1989; Mohsini and Davidson, 1992), and *interdependence among participants* (Higgin and Jessop, 1965; Mohsini, 1989). These characteristics influence how the project coalition (PC) conduct their respective activities and interact with each other. The interrelationships of the PC ultimately determine overall project performance in terms of finished product and the performance and satisfaction levels of the participants.

The UK construction industry has long been criticised for engendering adversarial relationships among project participants. That is, participants tend to focus on achieving their own objectives, with little or no regard for the objectives of others (Thompson and Sanders, 1998). Sometimes, the objectives of one participant are attained at the expense of others. If this situation pertains, all participants will suffer in the long term. That is, a participant may gain short-term benefits but these may often be at the expense of long-term benefits derived from (i.e.) harmonious working relationships.

The Latham report (1994) encouraged 'win-win solutions' to modern-day construction problems. All construction participants should strive to improve their performance and acquire goal attainment; leading to satisfaction. This will derive long term mutual benefits for the PC. Enhanced client satisfaction will encourage more clients to enter, or greater utilise the industry in the future. Ultimately, the construction industry and the UK economy as a whole will benefit through a greater workload, improved quality, improved satisfaction and less waste, etc., i.e. continuous improvement. However, the Egan report (1998) revealed that many clients are still dissatisfied with the performance of their contractors and consultants. The construction industry has also been critised for its failure to meet its own, and its clients' needs.

Harmonious working relationships and high degrees of co-operation between the PC are pre-requisites to effective team performance and project success (Baker *et al.*, 1988; Smith and Wilkins, 1996; Egan, 1998). In this context, success means that certain expectations for a given participant are met, whether this be the client, the contractor, the designer or all of these (Sanvido *et al.*, 1992). However, harmonious working relationships between participants are rarely found (Smith *et al.*, 1998). Participants are often involved in protracted contractual disputes leading to costly settlement, arbitration or legal action. This adversarial nature is of course, far from the expectation of participants. One of the reasons why this situation emerges may be that each participant has their own 'agenda' for a particular project, which ultimately conflicts with those of other participants (Gardiner and Simmons, 1992). However, the root cause of this adversarialism is that participants are often far from satisfied with the performance of others which consequently influences the achievement of a participants' own project objectives. Therefore, there is a need to investigate the interrelationships between participants in term of their performance and satisfaction. This will broaden understanding of these complex interrelationships, promote effective participant performance, reduce conflicts and foster harmonious working relationships.

This research considered performance and satisfaction interrelationships between the client, architect and contractor. These participants are traditionally the main participants in the project coalition (e.g. ASCE, 2000). While the other participants (e.g. engineers, quantity surveyors) may be influential, the research chose to focus on the main participants partly because of resource constraints, but also as this allowed the research to be more focused. The selection of participants was also influenced by the fact that the traditional procurement route is still relatively dominant at present as confirmed by the results of the survey (refer to section 7.2 and Table 7.3). In the traditional route, the client, architect and contractor represent the three principal participants involved (Walker and Chau, 1999). However, this does not mean that the research findings are only applicable to the traditional procurement route. The principles can also be applied to other procurement routes (e.g. design build, partnering) since relationships between the participants of the construction PC still exist.

1.2 AIM AND OBJECTIVES

Within the context of the PC and the interdependence among its participants, this research will consider the possible performance and satisfaction interrelationships between clients, architects and contractors, with a view towards helping to reduce adversarialism and improve the performance and satisfaction of each participant. To accomplish this, satisfaction levels must be predicted in order to anticipate the final (i.e satisfactory or otherwise) outcome of a particular project. As a general hypothesis, if the performance of each participant is improved, project performance will be enhanced. Better project performance should bring with it higher client satisfaction, since client objectives often manifest in project objectives.

Hence, the main aim of this research is to examine the interrelationships between participant performance and the satisfaction levels of other participants, leading towards developing a better understanding of the determinants of satisfaction. The ultimate goal is to develop models of satisfaction for each participant based on a framework of mutual performance assessment. The models will predict satisfaction levels for participants of the PC at various stages (e.g. before commencement of work on site); thereby enabling suitable actions to be implemented. This may ultimately help enhance overall project performance due to a more co-operative and performance enhancing PC. The fundamental research question to be addressed therefore is:

> "In the context of the construction PC and the interdependency of the main participants (clients, architects and contractors), what determines the satisfaction of each participant?"

The implications raised by this question will now be discussed using contractor performance as an example. The performance of the contractor may be assessed by the other two PC participants, namely the client and the architect. In conducting this performance assessment, the two participants are likely to apply different criteria. The question is then, what criteria are used by the client and/or architect in assessing the performance of a contractor and how do these influence their satisfaction. Knowledge of these performance criteria and determinants of satisfaction, especially those within the control of the contractor, should enable the contractor to better satisfy the client and the architect. This process can also be applied to the other participants. Therefore, if the relationships between these criteria and determinants are known and understood, satisfaction levels could be predicted with reasonable accuracy and consistency. Hence, the research hypothesis is:

> "Satisfaction levels of each participant are dependent on several attributes which in turn can be used to predict satisfaction levels with reasonable accuracy and consistency."

In pursuit of this primary aim, the principal research objectives embrace the following:

i) To investigate the nature of interrelationships between main participants of the PC based on an in-depth literature review, encompassing the fields of construction, organisational sociology, psychology and behaviour;

ii) To identify the determinants of satisfaction, which include participant performance attributes, project attributes, and assessor attributes;

iii) To identify performance criteria for each participant in the context of their satisfaction / dissatisfaction;

iv) To develop principal data collection instruments, i.e. PC questionnaires;

v) To administer UK-wide questionnaire surveys of clients, architects and contractors;

vi) To conduct preliminary data analysis for identifying potentially statistically significant independent variables;

vii) To explore the characteristics of projects involved in this research (i.e. case projects) using descriptive and bi-variate analyses;

viii) To prepare data acquired from the questionnaire surveys for modelling;

ix) To determine a legitimate measure of satisfaction to be used as a dependent variable in the models;

x) To assess the validity and reliability of the satisfaction measure(s) for use as dependent variables in the development of models;

xi) To develop models of satisfaction for each participant using appropriate techniques;

xii) To validate the models through rigorous testing using data not used in the modelling process;

xiii) To disseminate broadly the research findings for the benefit of industry, academia and the research community.

1.3 MODEL INTRODUCTORY

In light of the research aim and objectives, the following major attributes were identified as potential variables to be included in the model:

- Performance attributes (of a participant) are the characteristics or nature of a particular participant, and/or their employing organisation, such as company age, turnover, etc., which may influence their ability to perform.
- Project attributes represent the characteristics / nature of a project, which comprise controllable and uncontrollable attributes. Project attributes indirectly affect performance and are inherent within the project. In other words, project attributes define the characteristics / nature of the project, representing the 'environment' in which the participants must perform. Controllable attributes are for example, forms of contract, procurement route, extent of design finished prior to work on site. Uncontrollable attributes are type of project (e.g. new build, refurbishment) and building (e.g. office, retail), ground and weather conditions.

- Assessor attributes represent the characteristics of the assessor (that is the participant who is carrying out the assessment) which may influence their assessment. For example: experience, vocational background.
- Company assessor attributes are characteristics of the assessor's company, which may also influence their assessment. Assessor and company assessor attributes form a frame of reference for the performance assessment (i.e. satisfaction judgement).

Figure 1.1 depicts a simple model demonstrating the relationships between the variables employed.

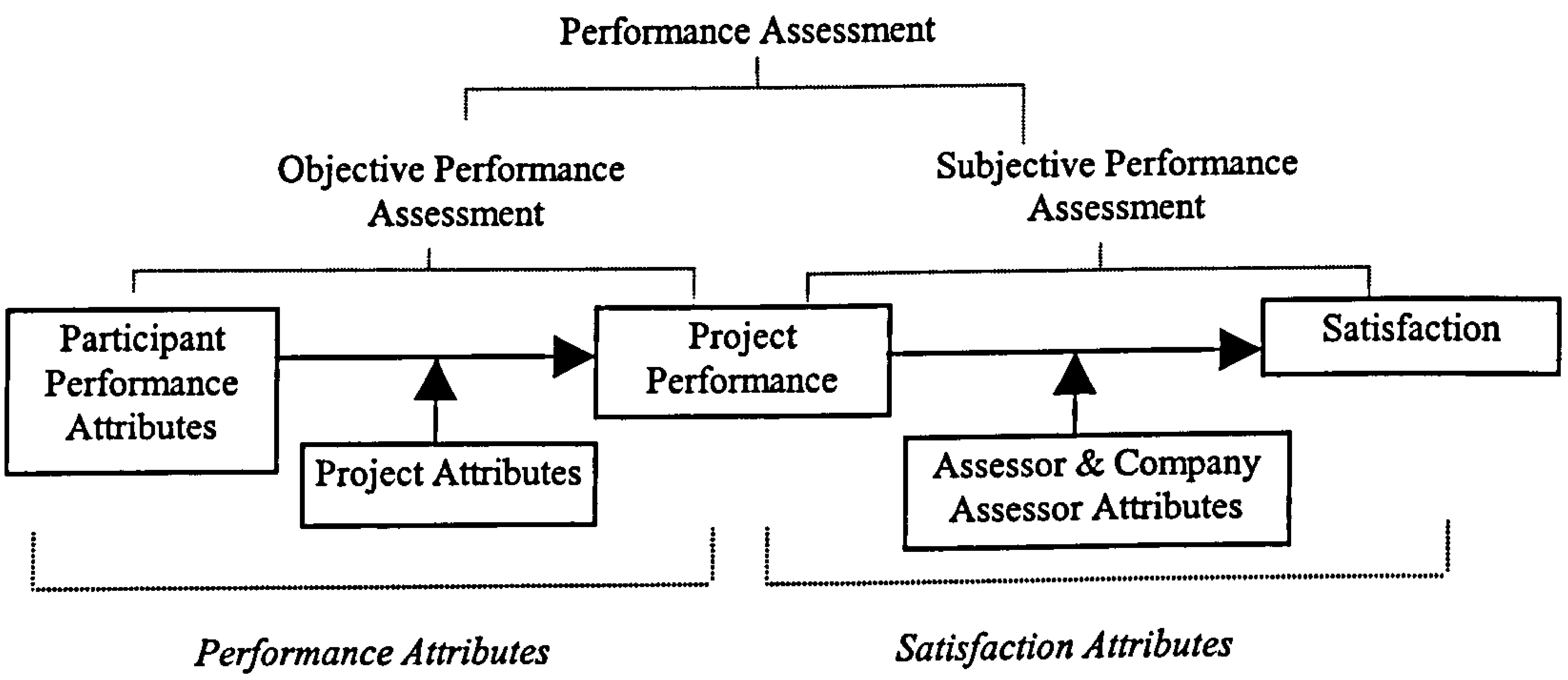


Figure 1.1 Introductory research model

The performance attributes of a participant have a direct influence on their own performance in the construction process. Project attributes indirectly influence the participant's performance since the attributes may enable / hamper the participant in executing their duties. Performance assessment in this respect is considered as 'objective' (i.e. tangible) in nature. For example, contractor performance may be assessed in terms of cost, time and quality performance (Holt, 1995).

However, performance assessment goes beyond the objective aspects outlined above since the intuitive feelings of the assessor need also to be considered, which in turn are dependent on their background, i.e. frame of reference. This assessment is considered 'subjective' and at a higher level. This research embraces both 'objective' and 'subjective' (or higher level) performance assessment (refer to Figure 1.1).

1.4 RESEARCH STAGES

Figure 1.2 depicts a flow chart of the various stages of the research. Each stage represents a process which has an input as well as an output with some outputs forming the inputs of succeeding stages. An overview of these various stages now follows:

1.4.1 Stage 1: Problem Identification

Problem identification is an important part of any research. A clearly identified and focused research problem helps lead to a smooth research. Problem identification was undertaken based on a review of relevant literature and discussions with the supervision team. This led to identification of the main problem statement, research question, hypothesis, aim and objectives, representing the outputs of this stage.

1.4.2 Stage 2: Domain Definition

This stage served to provide a solid foundation for the research. This involved a desk study including a review of literature to help identify the most appropriate research methods for the purposes of satisfying the research objectives. Whereas the problem identification stage sought to confirm the main research aims, this stage sought ways to achieve those aims. The outputs of this stage were development of a conceptual model, methodology design and research flow.

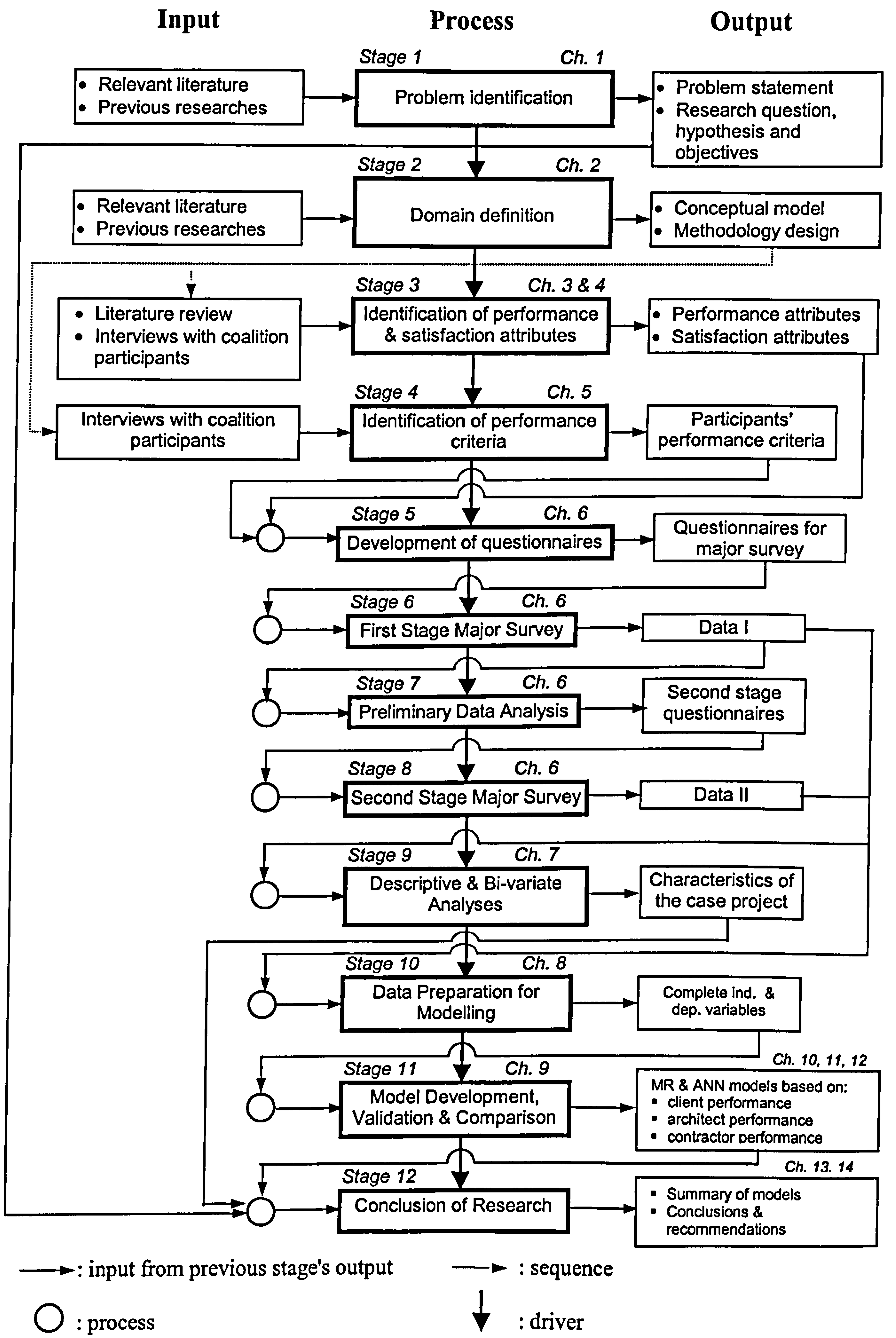


Figure 1.2 Research flow chart

1.4.3 Stage 3: Identification of Performance and Satisfaction Attributes

This stage involved a thorough literature review in the domain of performance (i.e. participants and project) and satisfaction (i.e. psychology, organisational behaviour and marketing research). Additionally, interviews also revealed several important attributes. The outputs from this stage were identification of participants' performance attributes, project attributes and satisfaction attributes, i.e. assessor and company assessor attributes.

1.4.4 Stage 4: Identification of Performance Criteria

Performance criteria for each participant were identified from interviews with practitioners. Interviews were justifiably chosen as the most appropriate method to elicit these as they allowed exploration of the feelings and other subjective / intuitive factors of the interviewees. This being essential in performance assessment.

1.4.5 Stage 5: Development of Questionnaires

In order to collect the data required for model development, a UK wide questionnaire survey was undertaken. This method was chosen because it allowed a number of issues to be compared, e.g. between different procurement routes, i.e. traditional and partnering, different types of building projects, and different types of clients. Further, this method was also able to capture the underlying performance and satisfaction attributes influencing feelings of satisfaction / dissatisfaction. Thirdly, development of the intended models demanded a large volume of data for developmental purposes.

The attributes and criteria identified in stages 3 and 4 were developed into three questionnaires intended to capture participants' experiences of recently procured projects. This was to enable 'real' satisfaction / dissatisfaction feelings to be assessed. The questionnaires were piloted with the co-operation of practitioners whom had previously been interviewed in an earlier stage of the research. Comments on the lay-out, clarity and comprehensiveness of the questionnaire were yielded and used to help improve the final questionnaires.

1.4.6 Stage 6: First Stage Major Survey

This stage involved distribution of the questionnaires to clients, architects and contractors. Top UK architects and contractors, and experienced private and public clients were targeted as respondents. The questionnaires were addressed to top executives within these organisations.

1.4.7 Stage 7: Preliminary Data Analysis

In this stage, data obtained from the first stage major survey and pilot survey, was analysed to identify potentially statistically significant variables. The purpose of this analysis was two fold: first, to obtain a more manageable (i.e. smaller) number of variables which had the potential to be important variables and so allow efficient and effective analysis to be conducted; and second, to reduce the length of the questionnaires to be used in the second stage survey in order to obtain the response required to allow further meaningful statistical analysis.

1.4.8 Stage 8: Second Stage Major Survey

This stage involved distribution of the second stage (i.e. reduced) questionnaires to clients, architects and contractors.

1.4.9 Stage 9: Descriptive and Bi-variate Analyses

Descriptive and various bi-variate analyses were applied to significant project attributes in order to explore the characteristics of the case projects. The aim was to acquire information that could be useful for subsequent interpretation of the models developed.

1.4.10 Stage 10: Data Preparation for Modelling

In this stage, data collected from the pilot and major surveys, was then prepared for modelling. This involved addressing missing values contained in the data, preparation of independent variables (including treatments for multicollinearity and binary dummy variables transformation), and finally, investigation of a legitimate measure of satisfaction to be used as a dependent variable (including application of the principal components analysis, Pearson's correlation technique and validity and reliability tests performed on the satisfaction measures).

1.4.11 Stage 11: Model Development, Validation and Comparison

This stage involved modelling using two potentially appropriate techniques, namely multiple regression (MR) and artificial neural network (ANN). The MR technique was chosen because of its ability to predict levels (i.e. values) of satisfaction and because the results of preliminary data analysis showed some degree of linear relationship between dependent and independent variables. That is, MR represented an appropriate methodology for data of this nature. Further, the ANN technique was applied because of the nature of the research problem which demanded a somewhat more 'sophisticated' tool to reveal the attributes underlying complex and noisy (i.e. very subjective) satisfaction judgements. The reliability and robustness of the models were tested and confirmed using independent (hold-back) data, i.e. that which had not been used to develop / train the models. The MR and ANN models were also compared in terms of their performance and independent variables identified.

1.4.12 Stage 12: Conclusion of Research

The main findings were summarised and discussed. Potential practical application of the models was presented and the strategic implications of the research findings on the construction PC described. A review of the research objectives and limitations of the research were discussed. Recommendations for possible further research in the domains of performance and satisfaction in the context of the construction PC were made.

1.5 CONTRIBUTION TO KNOWLEDGE

This research offers several significant contributions to knowledge which are considered as the following:

- The research investigated the interrelationships, in terms of performance and satisfaction between main coalition participants, i.e. clients, contractors, and architects. This is significant in terms of developing an awareness and understanding of the influence of a participant's performance / satisfaction attributes on satisfaction levels. This should lead to enhanced working relationships between participants of the PC. Previous research has focused on the performance of individual participants often, from just one point of view. This research has taken a more informed view of the complex interrelationships that exist incorporating the main stakeholders in the PC.
- Due to the subjective nature of performance assessment, assessor and company assessor attributes (i.e. satisfaction attributes) were included in the modelling as it was suspected that these attributes had an impact on satisfaction. Similarly, previous research in this domain has not considered the attributes of the assessor.

- The main outputs of the research are the models for predicting satisfaction levels of main participants of the PC. The development of such models has not previously been attempted, let alone achieved.

1.6 ORGANISATION OF THIS THESIS

This thesis describes the research work which has been conducted and embraces the following organisation:

Chapter 2 – This chapter presents a review of the nature of performance and satisfaction interrelationships in the construction project coalition. It provides explanation of the interrelationships between clients, architects and contractors. In the final section, a conceptual model of performance and satisfaction is presented representing the foundation for this research.

Chapter 3 – This chapter compiles attributes influencing performance as identified from the literature. This includes attributes influencing contractor, architect and client performance, as well as project performance. The final section describes and lists the attributes selected for this research.

Chapter 4 – This chapter discusses attributes influencing expressed levels of satisfaction as identified from the literature. The concept of satisfaction and its importance in the evaluation of project outcomes is discussed, followed by a description of the relationship between performance and satisfaction in the context of performance assessment. The final section describes a review of the literature on antecedents of satisfaction, and lists the satisfaction attributes developed for this research.

Chapter 5 – This chapter reports on the interviews that were conducted and the resultant findings. Firstly, justification of interviews as a main research method is discussed. Secondly, the interview method, questions, interviewees and analysis are described. Performance criteria for each participant are then listed and described. Finally, participant attributes identified are presented and described.

Chapter 6 – This chapter describes the methodology used to collate data for modelling purposes. The development and distribution of the questionnaires is explained, preliminary data analysis is described in detail, and results of pilot and major surveys are then presented.

Chapter 7 – This chapter presents the results of descriptive and various bi-variate analyses performed on the significant independent variables related to the case projects. The aim was to explore the characteristics of the case projects and to acquire information that could be useful for subsequent interpretation of the models developed. First, the results of the descriptive analysis of each variable were presented and described. This was followed by the results of various bi-variate analyses to explore the interrelationships between the variables.

Chapter 8 – This chapter presents the preparation of data for modelling including methods used to deal with missing values and preparation of independent and dependent variables.

Chapter 9 – This chapter describes in detail the modelling techniques employed including MR and ANN techniques. In addition, methods to assess the performance and validation of the models are established and explained.

Chapter 10, 11, 12 – These chapters present the various models of satisfaction for clients, architects and contractors respectively. Key issues highlighted by the models are also discussed.

Chapter 13 – This chapter provides a summary of the models, together with the significant findings drawn from the work. The potential practical application of the models is then described. Strategic implications of the findings for the construction project coalition (PC) are finally discussed.

Chapter 14 – This chapter concludes the thesis and provides a review of the research objectives and achievements. Limitations of the research are acknowledged and finally recommendations for possible further research are discussed.

1.7 SUMMARY

Despite the importance of harmonious working relationships between participants in the construction project coalition, adversarial relationships between those participants are evident. The root cause of this problem is in the performance and satisfaction interrelationships shared by the key participants. Generally, that is, participants are often far from satisfied with the performance of others. The primary aim of the research is to develop models of satisfaction based on the mutual performance assessment of participants in the PC.

This chapter has presented the initial research model and flow chart designed to satisfy the research aim and objectives. The expected contribution to knowledge afforded by the research has been described. Finally, an account of the organisation of this report has been presented.

Chapter 2

Performance and Satisfaction Interrelationships in the Construction Project Coalition

2.1 INTRODUCTION

This chapter presents a review of the interrelationships between performance and satisfaction in the context of the construction project coalition (PC). Based on the literature reviewed including that from the fields of psychology, organisational behaviour and sociology, a conceptual model is presented.

2.2 BASIC CONCEPTS UNDERLYING THE MODEL

The performance and satisfaction interrelationships between participants in the PC are complex in nature, and therefore need to be explored and modeled. The following sections describe the basic concepts of the model based on a review of salient literature.

2.2.1 Definition of Project Coalition (PC)

The PC is a temporary multiorganisation (Cherns and Bryant, 1984; Reve and Levitt, 1984; Mohsini, 1989; Mohsini and Davidson, 1992) that undertake construction projects for client organisations. Traditionally, main participants of the PC are *the client, the contractor* and *the architect.* These participants appoint persons / teams to represent their organisations in the PC.

2.2.2 Interrelationships between Main Participants of the PC

The interrelationships between participants of the PC contribute significantly to overall project performance. Performance is most effectively measured by levels of satisfaction. Each member has to be satisfied with the performance of the other participants if good working relationships and suitable levels of cooperation are to be sustained. Here, performance is defined in terms of roles within the PC, while satisfaction is defined in terms of roles in the process. The performance and associated satisfaction levels of other participants (e.g. suppliers, subcontractors) is outside the scope of this research.

2.2.3 Interdependence among Participants: A View of Organisational Sociology

While relationships among participants are temporary, they are highly interdependent in nature (Higgin and Jessop, 1965; Mohsini, 1989). Coalition participants require certain actions to be undertaken by others in order to enable them to perform their own respective tasks. This is defined by Bates (1960) as a *reciprocal relationship*. Hence the performance of a participant depends to some extent on the performance of others. The relationship between participants can also be partly described as a *conjunctive relationship*. That is, for a participant to perform their function or accomplish their goal they must conduct their task in conjunction with another (Bates, *ibid.*). Bates (*ibid.*) argued that the difference between reciprocal and conjunctive relationships is in terms of goal orientation. In the former, all participants have a common goal. However, in the latter each participant has an individual goal which can be distinguished from other participants' goals. Thus, it can be demonstrated that participants of the PC each have their own goals, but also share the common goal of delivering the final product, i.e. the project under construction, to the client's satisfaction.

According to basic organisational theory, a particular organisation is composed of interdependent parts (Thompson, 1967; Silverman, 1970). Thompson (1967) discovered the types of interdependence and coordination between such parts. The nature of interdependence and coordination between participants of the PC can be catagorised as *reciprocal interdependence* and *coordination by mutual adjustment.*

Reciprocal interdependence is where the outputs of a participant become the inputs of others and vice-versa. Thompson (1967) contended that if an organisation is involved in reciprocal interdependence then it will also include *pooled* and *sequential interdependence* (considered as lower level types of interdependency). Pooled interdependence occurs when each part of an organisation is least dependent on other parts; but each part discretely contributes to the whole organisation and is supported by the whole. Sequential interdependence (which is less dependent than reciprocal interdependence but more dependent than pooled interdependence) is where an outcome of one part of the organisation becomes an input for another part; but the output of the latter does not become the input for the former.

Each type of interdependency requires a specific type of coordination. Pooled interdependence requires coordination by standardisation. Sequential interdependence needs coordination by planning. Coordination by mutual adjustment, which is required by reciprocal interdependence, involves effective communication of new information and decisions during the action (i.e. construction processes). Moreover, the more variable and unpredictable the situation, the greater the reliance on coordination by mutual adjustment (March and Simon, 1958 cited in Thompson, 1967). It may be concluded that the more complex the interdependency, the more complex the interactions and the interrelationships between parts of an organisation become. An example in the construction project environment would be where the contractor requires drawings from the architect; who in order to keep up to date with conditions on site, requires certain information from the contractor which can then be incorporated into drawings. This example illustrates the reciprocal interdependence and the coordination by mutual adjustment which requires appropriate communication and decision making.

Moreover, Mohsini (1989) argued that interdependence can be symmetrical or asymmetrical (i.e. both or only one of the two concerned organizations has incentive to co-ordinate), and it can range from high to low. Symmetrical interdependence is where both participants comply to each others requirements. In contrast, asymmetrical interdependence occurs where one participant has to comply to another participant, but the latter does not have to comply to the former. Symmetrical interdependence between organisations may promote collaboration while asymmetrical interdependence may lead to conflict.

2.2.4 Relationships between Performance and Satisfaction: A View of Psychology and Organisational Behaviour

Back in the late 1960s, Locke established the theory of task performance and satisfaction in the field of organisational behaviour and psychology (Locke, 1970; Locke *et al.*, 1970; Locke and Latham, 1990). The theory argues that performance is most effectively determined by the achievement of goals, while satisfaction is a function of the discrepancy between performance achieved and performance targeted. In other words, satisfaction is a function of comparison between an individual's perception of an outcome and their expectation for that outcome (Ilgen and Hamstra, 1972).

Furthermore, Locke (1969) reported that the emotional responses (i.e. feelings of satisfaction and dissatisfaction) are also dependent on value importance; that is how an individual deems a certain aspect of the task in their value hierarchy. Leading from this, the implications for participants of the PC are now considered. That is, how one participant of the PC values a certain task undertaken by another participant; and how this impacts their own performance and levels of satisfaction.

The extent to which the performance of other coalition participants impacts upon the performance of another will determine that participant's perceived importance of the others performance. This is because the satisfactory performance of 'other' coalition participants enables another participant to achieve their own goals and to perform better. From this discussion, two levels of satisfaction may be postulated. First, the satisfaction of a coalition participant upon achieving the goals of their own organisation, and secondly, the satisfaction of a participant derived from the performance of other participants.

In construction, performance is an individual's (client, architect, contractor) contribution to the execution of the task required to complete the project (Liu and Walker, 1998). Therefore, it can be said that the performance of each participant contributes to overall project performance. The performance of one participant does not necessarily bring satisfaction to other participant(s) directly; the linkage is far more complicated. The performance achieved by one participant affects the goal attainment of other participants. The attainment of goals may bring satisfaction to those participants affected by such attainment. Therefore, goal attainment is considered as a first level outcome whereas satisfaction is considered as a second level outcome (Liu and Walker, 1998).

Concerning the second level of satisfaction, each participant sets the expected goal levels of others. For instance, the client desires certain levels of performance (goal levels) from the architect and contractor, which affect attainment of the client's goal. If the performance of the architect and contractor exceed the goal level expected, then the client perceives that they have succeeded the tasks assigned to them. This will provide a feeling of satisfaction to the client. However, the client's level of satisfaction may vary based on how much the goal levels have been exceeded. Therefore, criteria or other quantitative measures are needed for comparing goal levels against performance levels thus giving a goal / performance discrepancy index to show the degree to which the goals have or have not been achieved. Evaluation outcomes represent success or failure and / or subsequent feelings of satisfaction or dissatisfaction (Liu and Walker, 1998).

2.2.5 The Relationship between the Performance of PC Participants

The performance of one participant is, to a certain degree, affected by the performance of another. This is described by Hamner and Harnett (1974) as a *cooperative-interdependent task*, i.e. where the performance of an individual is partly determined by how well another perform their tasks. Arge (1995) for example, indicated that architectural quality is determined by client performance. A qualified client is instrumental in securing good architecture (Arge, *ibid.*). Kometa *et al.* (1994) argued that certain attributes associated with client organization also affect the consultant's performance and, hence, construction project performance. Moreover, Tam and Harris (1996) identified external factors affecting contractor performance consisting of other participants' performance, i.e. architects and clients. These factors included architect/engineer drawings, architect's or client's supervision and control of the quality of work, control of work progress, and punctuality of payment by the client.

2.3 A CONCEPTUAL MODEL OF PERFORMANCE AND SATISFACTION IN THE CONSTRUCTION PC

Figure 2.1 shows the performance model for individual organisations (the contractor in this case) of the PC. Performance within the PC is a manifestation of the performance attributes (i.e. characteristics of that organisation, such as past experience, turnover, references), and is driven by performance objectives. In sum, it is shown that the performance of each participant contributes to overall project performance.

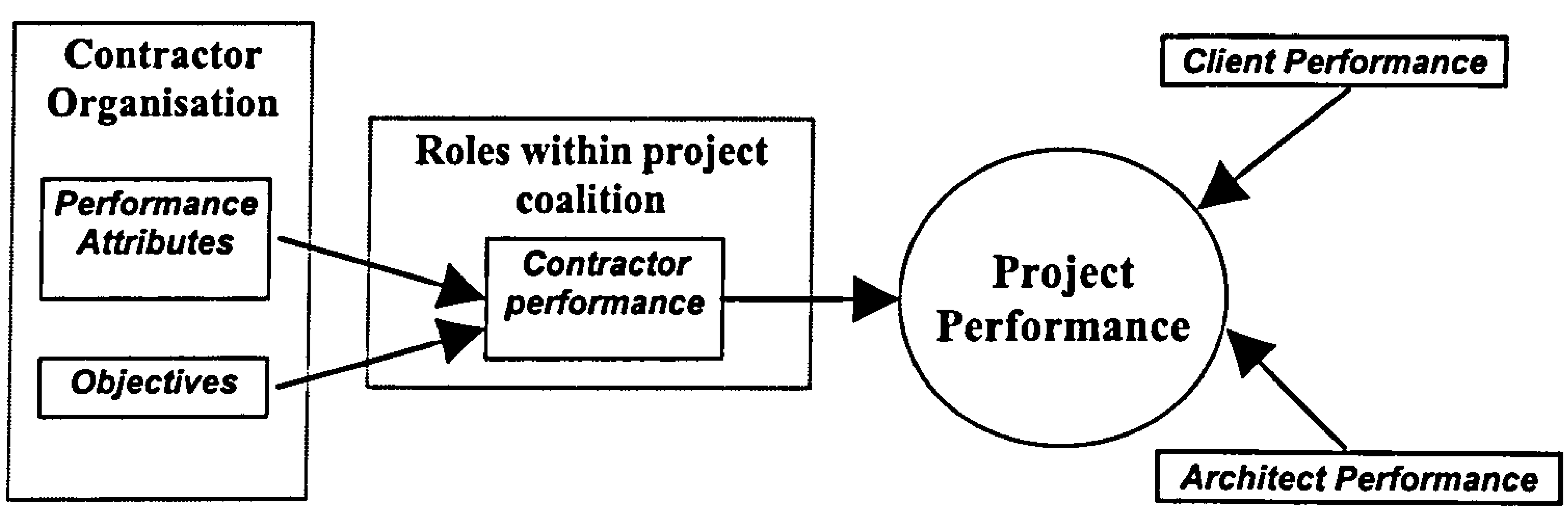
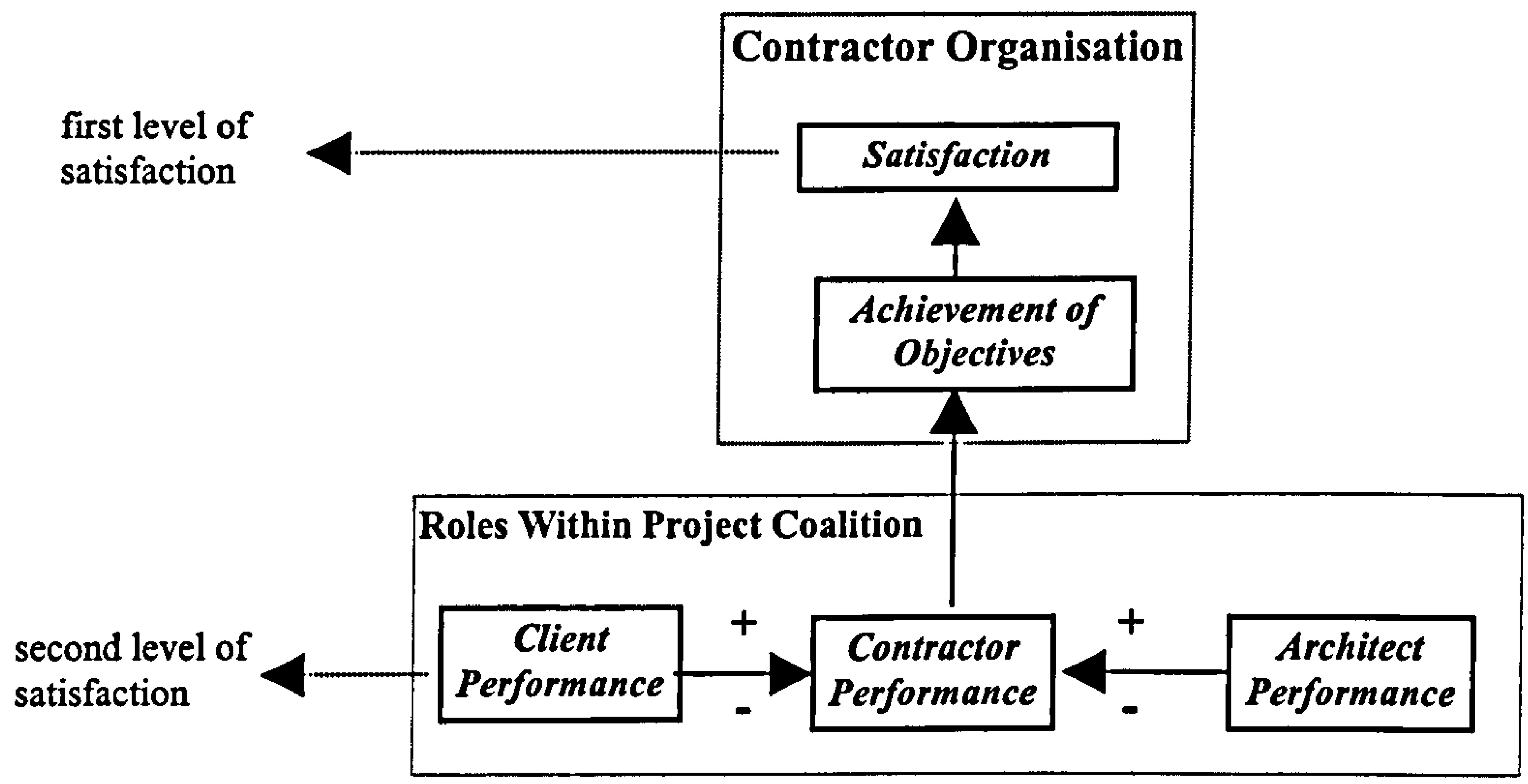


Figure 2.1 Performance model for contractor

Figure 2.2 illustrates the performance and satisfaction model for individual organisations (e.g. contractor) of the PC. It shows how performance brings satisfaction for one participant (in this case the contractor) through the achievement of their objectives. With regard to the first level of satisfaction, achievement of objectives will bring satisfaction within the (e.g. contractor) organisation. However, the achievement of objectives may depend on the satisfactory performance of the other two participants, if and only if, in order to perform well, the contractor needs a certain level of performance from them. It also depicts the interrelationship between the performance of participants. The performance of one participant is not solely dependent on their own performance, but also on the performance of other participants. The performance of other participants when evaluated will create feelings of satisfaction or dissatisfaction for that participant. This is the second level of satisfaction. The horizontal links shown in Figure 2.2 indicate how each participant evaluates the performance of other participants.



Note: + : satisfactory performance evaluation, - : unsatisfactory performance evaluation

Figure 2.2 Performance and satisfaction model for contractor

Figure 2.3 shows as a whole, the relationships and interrelationships between performance, satisfaction, attributes and objectives of all participants in the PC. It is worth noting that the second level of satisfaction, which is derived from the outcome of the evaluation of others' performance, may *explicitly* bring good working relationships between participants of the PC since a participant performance directly impacts project performance and the performance of others. However, the first level of satisfaction, which is within the individual organisation, is derived from the achievement of organisational objectives. The performance of other participants may enable a participant to perform certain actions which could lead to the achievement of these objectives. This is at the core of satisfaction / dissatisfaction feelings which, at certain levels, may *implicitly* bring good working

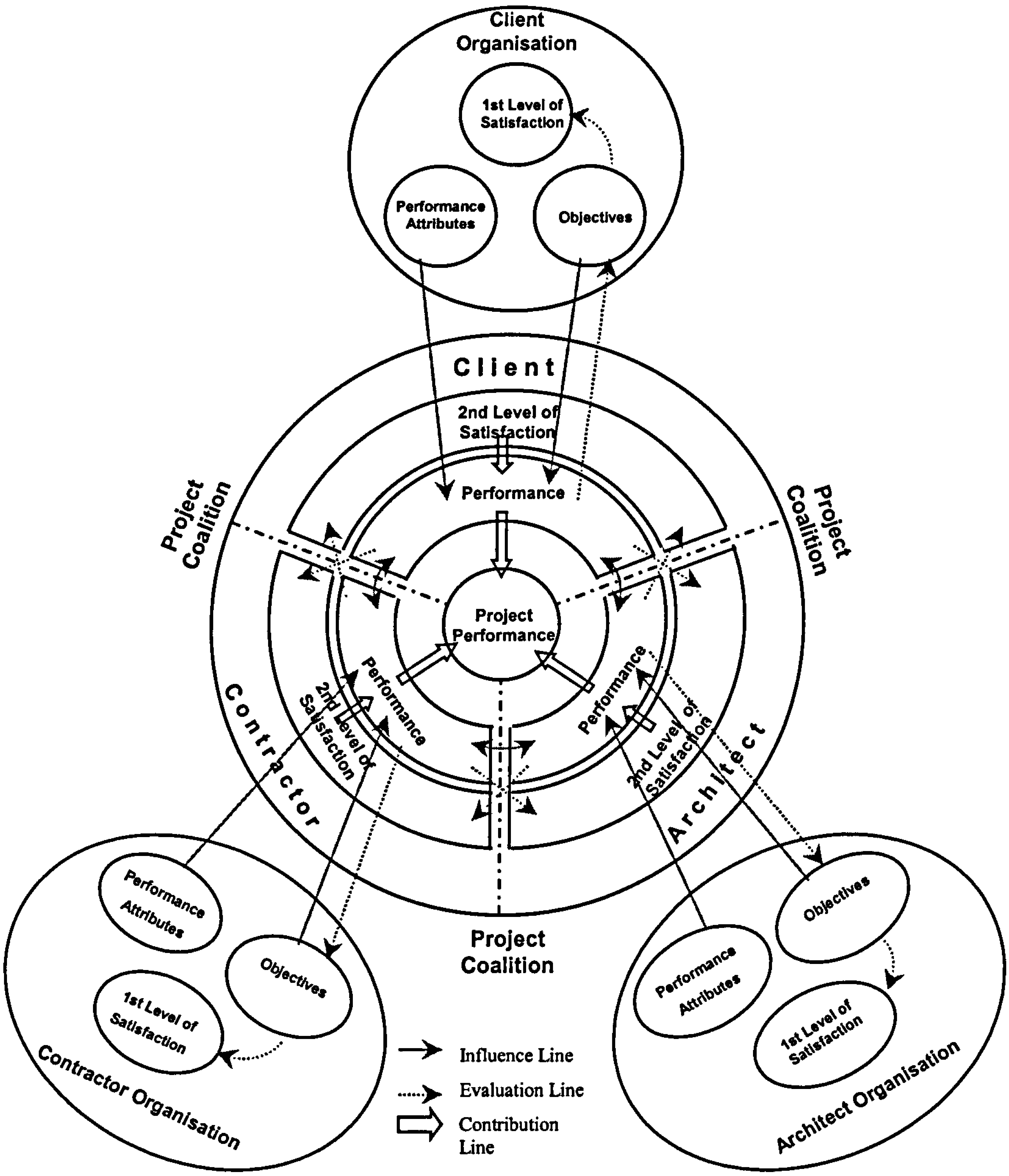


Figure 2.3 Performance and satisfaction model for main participants of the PC

relationships between participants of the PC. That is, the achievement of organisational objectives may indirectly impact project performance and the performance of others, and ultimately derive satisfaction /dissatisfaction feelings in undertaking a particular project.

2.4 SUMMARY

It has been recognised that interrelationships, in terms of performance and satisfaction, between participants in the PC are complex in nature, and therefore need to be explored and modeled. This chapter has discussed possible performance and satisfaction interrelationships between those participants based on a review of the literature. The model presented indicates the importance of mutual performance assessment, which is the focus of this research, and gives due regard to satisfaction / dissatisfaction feelings. Satisfaction is important because it is a pre-requisite to harmonious working relationships between participants, and for successful project implementation. Therefore, there is a need to identify performance and satisfaction attributes, and performance criteria so that this conceptual mutual performance assessment model, can be developed, tested and refined in practice. This is the focus of the following three chapters.

Chapter 3

Performance Attributes: A Literature Review

3.1 INTRODUCTION

To address the main research question[1], the first primary task is to identify the attributes that influence each participant's satisfaction. These attributes are categorised into performance and satisfaction attributes. Performance attributes consist of participant and project attributes. This chapter presents a review of literature concerning attributes influencing participant and project performance. The attributes selected, which were to form the basis of the major survey and subsequent analysis, are also discussed. The following chapter then addresses the identification of satisfaction attributes.

3.2 PARTICIPANT ATTRIBUTES

This section describes a review of literature concerning participant attributes. Participant attributes directly affect participant performance and are inherent within a participant and/or that participant's organisation or team for a particular project. Prior to discussion of attributes selected for further inclusion in this research, the attributes identified for each participant are presented.

3.2.1 Contractor Attributes

In the last ten years, extensive research in the domain of pre-qualification criteria and selection criteria for contractors has been undertaken. The underlying premise of such research is that the criteria utilised are presumed to have an influence on the future

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[1] "In the context of the construction PC and the interdependency of the main participants (clients, architects and contractors), what determines the satisfaction of each participant?" (see Chapter 1 for further explanation)

performance of a contractor. Therefore, the criteria used in pre-qualification are to some extent relevant and can be classified as attributes for this research. While such attributes are designed to aid the selection of contractor organisations, they are also of some relevance (with adequate adaptation) to architect and client organisations. The literature reviewed and attributes identified as influencing contractor performance are summarised in Table 3.1.

3.2.2 Architect Attributes

Contrary to extensive contractor performance research, there is relatively scant research regarding the performance of architects. This may be due to the fact that design fees are normally much less than the tender sum, hence there is less financial risk involved. Furthermore, architects are commonly appointed on the basis of their perceived reputation and/or by recommendation. That is, selection is far less systematic than compared to the process of contractor selection. However, several investigations have reported architect attributes including those for the selection of consultants (i.e. architects) by clients as presented in Table 3.2.

3.2.3 Client Attributes

Similarly, there is a dearth of research into the performance of clients. This is possibly due to the fact that as employers, the concept of assessing the performance of clients is somewhat 'alien'. However, Kometa (1995) has investigated the impact of client attributes on the performance of consultants. He argued that client performance is not a single attribute issue, but it depends on a number of closely interrelated but very important attributes. Additionally, Odusote and Fellows (1992) considered client related factors as the most important factors which contractors consider when making the decision to tender. Table 3.3 presents those attributes identified from the literature.

3.2.4 Discussion of Attributes

This section presents a discussion of the attributes identified from the literature (as shown in Tables 3.1, 3.2 and 3.3) and subsequently selected for inclusion in the research. That is, given the very high number of attributes, it would have been impractical to include all such in the survey. Therefore, criteria for attribute selection were developed based on the following:

- The ultimate goal of the research is to develop models of satisfaction for each participant based on a framework of mutual performance assessment. The models will predict satisfaction levels for participants of the PC at various stages (e.g. before commencement of work on site), so that guidance on the relative satisfaction achieved given project coalition attributes can be identified. Thus, attributes should be able to be determined and identified before the participants begin to work together. This obviously excludes process-related attributes (e.g. team turnover, frequency of site meetings).
- Those included should be representative of the principal attributes identified, and therefore may cover other sub-attributes that measure similar concepts.
- The attributes selected should be easily understood by the intended survey participants. It is unwise to ask questions which require respondents to refer to other documents as this may deter the respondents from responding to the survey.
- When a participant assesses another participant, the attributes should be accessible to the participant. That is, the attributes should not include confidential (i.e. financial) data because this may also discourage respondents from responding to the survey.

Table 3.1 Summary of attributes affecting contractor performance

Attributes affecting contractor performance / References	Sidwell (1982)	Jaselskis and Russell (1992)	Russell *et al.* (1992)	Russell and Jaselskis (1992a)	Russell and Jaselskis (1992b)	Assaf and Jannadi (1994)	Holt *et al.* (1994)	Assaf *et al.* (1996)	Bubshait and Al-Gobali (1996)	Dozzi *et al.* (1996)	Kumaraswamy (1996)	Russell and Zhai (1996)	Tam and Harris (1996)	Hatush and Skitmore (1997a, 1997b, 1997c)	Faniran *et al.* (1998)	Jennings and Holt (1998)	Cheung (1998)	Alsugair (1999)	Ng and Skitmore (1999)	Khosrowshahi (1999)
Firm characteristics																				
Contractor age (years in business)							●						●	●					●	●
Stability of the firm																			●	
Catchment (national or local)							●				●									
Origin of the company (overseas, joint venture, local, etc.)													●							
Company nationality																●				
Listed on the stock market													●							
Contractor is client's subsidiary firm													●							
Competitiveness																			●	
Integrity																			●	
Co-operative outlook																			●	●
Company informal contacts																●				●
Decision making centralised / de-centralised													●							
Capacity																				
Capacity of the firm (contractor)			●			●			●										●	
Current work load			●			●	●		●				●			●				
Classification of contractor (experience and reputation)																		●		
Number of employees					●															
Contractor size							●	●					●							
Working capital																			●	
Value of the project in hand																				●
Experience																				
Experience (general)									●					●						●
Experience (success of completed projects)			●					●												
Experience in geographical location of project			●			●	●		●		●									
Experience in the same type of project			●		●	●	●						●			●			●	●
Experience (number of job done/previous bids)											●								●	
Experience (average and largest value of jobs)											●									
Past experience (type of project completed)							●													
Past experience (size of project completed)							●													
Familiarity with the geo., social, ec., pol. aspects of site																		●		
Amount of work performed earlier									●											
Past performance & reputation																				
Past performance / performance rating			●			●				●	●		●	●					●	
Past performance in client's previous projects									●											
Quality performance / standard of quality			●			●													●	
Past performance (time overrun) / on time completion							●													●

Table 3.1 Summary of attributes affecting contractor performance (cont.)

Attributes affecting contractor performance / References	Sidwell (1982)	Jaselskis and Russell (1992)	Russell *et al.* (1992)	Russell and Jaselskis (1992a)	Russell and Jaselskis (1992b)	Assaf and Jannadi (1994)	Holt *et al.* (1994)	Assaf *et al.* (1996)	Bubshait and Al-Gobali (1996)	Dozzi *et al.* (1996)	Kumaraswamy (1996)	Russell and Zhai (1996)	Tam and Harris (1996)	Hatush and Skitmore (1997a, 1997b, 1997c)	Faniran *et al.* (1998)	Jennings and Holt (1998)	Cheung (1998)	Alsugair (1999)	Ng and Skitmore (1999)	Khosrowshahi (1999)
Past performance (cost overrun)							●													
Past performance (actual quality achieved)							●													
Reputation for low contract price																				●
Reputation for high quality service																				●
Contractor image							●						●			●				●
Past performance/reputation (failed to complete a contract)			●			●	●		●					●					●	
Company reputation (general)																●			●	
Claim attitude / claim and contractual dispute						●													●	
Litigation tendency							●													
Company trade union record																●				
Fraudulent activities																			●	
References / recommendations																				
References (general)			●			●			●											
Recommendation by consultants																				●
Financial issues																				
Financial stability / soundness			●		●	●			●		●			●		●			●	●
Bonding capacity			●																	
Financial consideration (etc., etc.)							●			●	●									
Difference between contract value and estimate								●												
Difference between contract value and next lowest bidder								●												
Personnel																				
Staff (key person) available / management staff			●			●	●		●											
Experience of project manager / site staff / key persons					●								●	●		●				
Personnel (past performance, qualification, experience)											●			●						●
Past performance of project manager													●							
Perception of commitment of project manager					●															
Project team turnover					●															
Qualification of owners							●													
Qualification of key persons							●						●			●				
Quality of technical and administrative staff																		●		
Years with company							●													
Skills and capabilities																				
Project management capabilities			●			●			●	●				●					●	
Technical capabilities / resources										●				●						●
Skills, expertise											●									
Company organisation and efficiency			●			●			●											●

Table 3.1 Summary of attributes affecting contractor performance (cont.)

Attributes affecting contractor performance / References	Sidwell (1982)	Jaselskis and Russell (1992)	Russell *et al.* (1992)	Russell and Jaselskis (1992a)	Russell and Jaselskis (1992b)	Assaf and Jannadi (1994)	Holt *et al.* (1994)	Assaf *et al.* (1996)	Bubshait and Al-Gobali (1996)	Dozzi *et al.* (1996)	Kumaraswamy (1996)	Russell and Zhai (1996)	Tam and Harris (1996)	Hatush and Skitmore (1997a, 1997b, 1997c)	Faniran *et al.* (1998)	Jennings and Holt (1998)	Cheung (1998)	Alsugair (1999)	Ng and Skitmore (1999)	Khosrowshahi (1999)
Company culture										●										
Management philosophy										●										
Management knowledge														●						
Organisation structure and style											●									
Company negotiating skill																●				
Resources (general)																			●	
Labour / manpower																				
Manpower recources			●			●			●											
Amount of directly employed labor													●							
Labour relation / specialised trade										●									●	
Amount of work performed with own forces			●			●														
Homogeneity of manpower								●												
Subcontractor																				
Partner subcontractors (experience)											●									
Quality of subcontractor																		●		
Relationship with subcontractors																			●	
Percentage of work subcontracted																		●	●	
Equipment / plants																				
Equipment / plant resources (inventory)			●			●	●		●		●			●						
Plant ownership policy													●							
Health and Safety																				
Safety performance (or safety records)			●			●				●										●
Health and safety policy/programme							●			●				●					●	●
Quality																				
Quality assurance and quality control policy/programme							●		●	●									●	●
Specific company programme																				
Formal training regime							●						●							
Specific environment programmes										●										
Substance abuse policy			●																	
Location																				
Location of home office			●			●	●		●	●						●		●	●	●

Table 3.1 Summary of attributes affecting contractor performance (cont.)

Attributes affecting contractor performance / References	Sidwell (1982)	Jaselskis and Russell (1992)	Russell *et al.* (1992)	Russell and Jaselskis (1992a)	Russell and Jaselskis (1992b)	Assaf and Jannadi (1994)	Holt *et al.* (1994)	Assaf *et al.* (1996)	Bubshait and Al-Goball (1996)	Dozzi *et al.* (1996)	Kumaraswamy (1996)	Russell and Zhai (1996)	Tam and Harris (1996)	Hatush and Skitmore (1997a, 1997b, 1997c)	Faniran *et al.* (1998)	Jennings and Holt (1998)	Cheung (1998)	Alsugair (1999)	Ng and Skitmore (1999)	Khosrowshahi (1999)
Project characteristics																				
Project size				●															●	
Complexity of the project													●						●	
Contract value								●												
Level of technology																			●	
Contracts																				
Poorly conceived contract document (unclear)				●																
Form of contract							●												●	
Flexible attitude towards contractual form																				●
Variations																				
Number of change orders								●												
External factors																				
Economics factors and market conditions					●							●								
Weather							●													
Design and designer																				
Percent of design completed prior to site work					●															
Experience of engineering design firm					●															
Experience of designer's project manager					●															
Architect / engineer performance													●							
Contractor relationship with consultants																			●	
Client / team related factors																				
Evaluation effort by client		●		●	●															
Client monitoring on contractor performance		●		●	●															
Previous experience with client				●			●													
Previous working relationship										●				●		●			●	●
Post-business relationship																				●
Shared understanding goals, objectives and interests										●										
Experience of client					●															
Architect's or client's supervision and control													●							
Punctuality of payment by the client													●							
Procurement																				
Procurement route / method of procurement								●											●	
Contractor selection criteria																	●			
Method of contractor selection	●																●			

Table 3.1 Summary of attributes affecting contractor performance (cont.)

Attributes affecting contractor performance / References	Sidwell (1982)	Jaselskis and Russell (1992)	Russell *et al.* (1992)	Russell and Jaselskis (1992a)	Russell and Jaselskis (1992b)	Assaf and Jannadi (1994)	Holt *et al.* (1994)	Assaf *et al.* (1996)	Bubshait and Al-Gobali (1996)	Dozzi *et al.* (1996)	Kumaraswamy (1996)	Russell and Zhai (1996)	Tam and Harris (1996)	Hatush and Skitmore (1997a, 1997b, 1997c)	Faniran *et al.* (1998)	Jennings and Holt (1998)	Cheung (1998)	Alsugair (1999)	Ng and Skitmore (1999)	Khosrowshahi (1999)
Degree of nomination																	●			
Process related issues																				
Project control procedure			●		●															
Monitoring during construction phase					●															
Reporting, monitoring and recording systems											●									
Progress of work																			●	
Execution plan (contractor programme)									●	●										
Response to instruction																			●	
Helpful and understanding in solving problem that arise																		●		
Maintain good relationship up to handover																		●		
Contractor senior management support					●															
Contractor early involvement					●															
Early completion dates																●				
Amount of planning effort expended					●	●														
Planning readiness prior on-site work															●					

Table 3.2 Architect attributes

References	Architect Attributes	Sub-attributes
Kasma (1987)	Technical experience	• general experience of the firm, and • experience in the specific project or tasks to be done
	Past performance / reputation	• reference to determine the quality of performance, • on-site inspection, • contact personnel operating a project, • how long has the architect been in business, • will the architect back up error they made
	Staffing	• availability of adequate personnel, equipment, facilities, • the name of the individuals to be assigned to the project with particular attention to their qualification, competence, and service with that firm
	Project approach and objectives	• the approach to the project work, • familiarity with the project site, • proposed time schedule for completing the work
	Proximity	• distance between the architect's office and project
	The questionnaire for architect selection should include these additional attributes: • Type of service(s) particularly qualified to perform; • Name of principals and their experience; • Name of key personnel, with experience, years in firm, type of specialization; • Number of staff; • Present activities: number of projects, estimated construction cost (work load); • List of completed work similar nature to this project (relevant experience); • References.	

continued.......

Table 3.2 Architect attributes (cont.)

References	Architect attributes
LePatner (1984)	Professional greatest asset is: • a reputation forged by the many relationships and interrelationships that develop over the years. *"Repeat commissions result from nurturing a reputation for* honesty, integrity and the delivery of a constantly high level of work product."
McKee (1993)	Architects' attributes are: • track record with adhering to schedules, • track record with adhering to budgets, • related prior experience on client's project type, • overall experience of the architectural firm, • references, • fees for the architecture services, • previous experience working for client, • membership in RIBA, • size of firm.
Naoum and Mustapha (1994)	Designer experience was found to influence project performance.
Finch (1995)	The survey of 600 client organisations showed that *"most clients appoint designers they know, rather than seeking competitive fee bids or design submission, but almost all appoint contractors on the basis of tenders."* (past experience with architects or architects whose clients are familiar with)
MacNeil (1997)	*"...to achieve the greatest technical value from its consultants, rather than going for a bid that is lowest but technically incompetent."* Technical bids will include information such as: (weight and score) • the company profile, • previous experience, • the technical approach to the project, • an outline of the resources the firm would apply to the project, and • the CVs of the personnel put forward to work on the scheme.
Dean (1998)	Criteria for selection are: • "*...deal with an architect we've worked before,*" • for new hire: "*...a more experienced one.*", • "*fee-based selection process.*", • "*...hires on the basis of qualification...*", • "*...but likes to have a broad knowledge about designers...*", • ask former clients: "*..whether the firm carried out its work on budget and on schedule, whether it solved the client's problems, whether it solved them in an innovative way, and whether the architects were good listeners.*" • "*... making selection based on a review of qualifications and recommendation, of proceeding from a long list to a short list and then to interviews.*" • "*...prefers local architect..national firms only if the firms have a local office.*" (location of office). • size of the firm.

Table 3.2 Architect attributes (cont.)

References	Architect Attributes	Explanation
ASCE (2000)	Ethics	The professional and ethical reputation of the architect, as determined by inquiries with previous clients and other references.
	Professional registration	Professional registration of the principals and other responsible members of the architect's organisation.
	Specific qualifications	The architect's demonstrated qualifications and capability to perform the scope of services, including knowledge of codes or other governmental regulations.
	Similar experience	Evidence that the architect has performed similar services on equal, or more difficult, projects.
	Resources	Evidence that the architect has the financial resources and business background to accept the assignment and provide full, continuous service.
	Availability	The architect's ability to provide appropriately qualified staff to the project and complete the required services within a time-frame that supports the project schedule.

Table 3.3 Client attributes

References	Attributes
Higgin and Jessop (1965)	Client's levels of sophistication: 'sophisticated' or 'naïve'
Nahapiet and Nahapiet (1985); Masterman and Gameson (1994)	Two characteristics for classifying clients are the following: • Primary or secondary constructors (*Secondary constructors* are clients for whom expenditure on constructing buildings is a small percentage of their annual turnover, and for whom buildings are necessary in order to undertake a specific business activity such as manufacturing. *Primary constructors* are clients whose main business and primary income derived from constructing buildings, such as property developers.) • Client's levels of construction experience (*Inexperienced clients* are clients who have no recent and relevant experience of constructing buildings, with no established access to construction expertise. *Experienced clients* are clients who have recent and relevant experience of constructing certain types of buildings, with established access to construction expertise either in-house or externally.
Odusote and Fellows (1992)	Client related factors, which are the most important factors contractors consider when making the decision to tender, are the following: • Client's ability to pay; • Regular client – good relationship; • Ability to provide client satisfaction; • Previous experience with client; • Identity of the client.
Naoum and Mustapha (1994)	Clients could be classified based on: • Level of experience (Three type of clients were i) an 'on-going' clients who build continuously and were classified as highly experienced clients, ii) an 'on-off' clients who build a number of projects in the past, say 2-3, and were classified as moderately experienced, iii) 'one-off' clients who build only one project in the past and were classified as inexperienced clients.) • Type (Clients could be either a speculative developer (publicly or privately funded) or a purpose built client who commissions buildings for their own use.)
Akinci and Fischer (1998)	Client-generated risk factors that can put a strain on the contractor's cash flow and increase the actual cost during construction, are: • Financial ability to meet the cost of the work, • Claims record, • Changing needs, • Construction sophistication, • Past experience.

Table 3.3 Client attributes (cont.)

References	Attributes	Sub-attributes
Kometa (1995)	Financial stability	current assets, creditworthiness, current liabilities
	Project feasibility	feasibility study, project priorities, personnel appointment, site condition
	Past performance	cost overrun, time overrun, quality achieved, unsuccessful projects, successful projects
	Project characteristics	type of project, size of project, cost of project, project complexity, objectives and sub-objectives, time, location
	Client's duties	project definition and formulation, project finance, contracting, legal agreement, human factors, project implementation and management, politics and social factors, schedule urgency, schedule duration, planning/design
	Organizational quality	organization of project team, coordination of project interphase, allocation of project resposibility
	Past experience	projects completed, construction activities, types of projects, experience of personnel
	Quality of management	project management, qualifications of personnel, project auditing, quality assurance
	Current market conditions	economic boom, economic recession
	Client characteristics	type of client, size of client, structure, communication channels, legal history

Based on the foregoing criteria, the following attributes were selected for inclusion in the major questionnaire surveys. Some attributes were found applicable to two or more of the coalition participants (clients, contractors and architects), while others were specific to just one participant. For the purposes of the discussion, the attributes have been categorised as generic or participant specific attributes as follows.

3.2.4.1 Generic attributes

Generic attributes are those that can be applied to all participants regardless of profession. An overview of such attributes now follows:

Company age

This attribute indicates how long the company has been in business. Older companies may possess more long-term stability (Holt *et al.*, 1994) and may be more reliable, e.g. more experience in controlling and managing works and/or more likely to have developed a company strategy aimed at seeking continuous improvement (Tam and Harris, 1996). Client organisations of a certain age are more likely to have experience of the construction industry due to their need for new facilities. Furthermore, well-established client organisations, will have stronger networks and financial sources.

Annual turnover

This attribute represents the financial capacity of the company. It is regarded as a measure of company size. Many studies have shown that this is a major variable in the performance of organisations (e.g. Sidwell, 1982). For architects and contractors, it indicates the amount of construction works they are currently handling. Selection of architects and, especially contractors is often based on project size (in terms of budget involved) and their annual turnover is used as a measure of their long-term capacity (Janssens, 1991 cited in Holt *et al.*, 1994). Furthermore, turnover may assist in the analysis of company activities and represents a constituent of several performance and stability ratios (Holmes and Sugden, 1990; and Pilcher, 1992 cited in Holt *et al.*, *ibid.*). This is to ensure that contractors and architects have adequate financial resources to undertake the project (ASCE, 2000). This is also true for clients, since they have to provide adequate funding for projects (Odusote and Fellows, 1992; Kometa, 1995; Akinci and Fischer, 1998; ASCE, 2000).

Number of employees

This attribute indicates the human resource capacity of the company. It may be a criterion used in contractor (Russell and Jaselskis, 1992b) and architect selection (Kasma, 1987; McKee, 1993; Dean, 1998). Clients who have large numbers of employees are likely to assign more personnel to handle their projects which may therefore have an indirect influence on their performance. An adequate number of employees is necessary but not sufficient alone to ensure satisfactory participant performance. However, it is considered as an important company attribute.

Work load

This criterion has previously been recommended for use in contractor (Russell *et al.*, 1992; Assaf and Jannadi, 1994; Holt *et al.*, 1994; Bubshait and Al-Gobali, 1996; Tam and Harris, 1996; Jennings and Holt, 1998) and architect selection (Kasma, 1987; ASCE, 2000). It measures whether a participant has adequate or spare capacity to handle the work (i.e. not overtrading). For clients, this refers to their construction procurement work load in their construction or property department.

Experience

Here, it is important to differentiate between the experience of the whole organisation, and the experience of key project personnel (see *Qualification and experience of personnel*, in section 3.2.4.1) since organisations may be highly experienced, but individuals within those organisations may be inexperienced (Sidwell, 1982). Experience has been regarded as one of the most important attributes, particularly in the context of contractor (Russell *et al.*, 1992; Russell and Jaselskis, 1992b; Assaf and Jannadi, 1994; Holt *et al.*, 1994; Assaf *et al.*, 1996; Bubshait and Al-Gobali, 1996; Kumaraswamy, 1996; Tam and Harris, 1996; Hatush and Skitmore, 1997a-c; Jennings and Holt, 1998; Ng and Skitmore, 1999; Khosrowshahi, 1999) and architect selection (Kasma, 1987; McKee, 1993; Finch, 1995; MacNeil, 1997; Dean, 1998; ASCE, 2000). Experience (related to construction) is also an important attribute of clients (Kometa, 1995). Experience related attributes which are deemed important and related to this research are relevant experience of the type and size of project, as well as experience in the geographical location of the project.

Past performance and reputation

Reputation is closely related to past performance and therefore these attributes have much in common. Effective past performance leads to the development of a good reputation. Similar to experience, past performance (as well as reputation) has been regarded as one of the most important contractor (Russell *et al.*, 1992; Assaf and Jannadi, 1994; Holt *et al.*, 1994; Assaf *et al.*, 1996; Bubshait and Al-Gobali, 1996; Dozzi *et al.*, 1996; Kumaraswamy, 1996; Tam and Harris, 1996; Hatush and Skitmore, 1997a-c; Jennings and Holt, 1998; Ng and Skitmore, 1999; Khosrowshahi, 1999), architect (LePatner, 1984; Kasma, 1987; McKee, 1993; Finch, 1995; Dean, 1998) and client attributes (Odusote and

Fellows, 1992; Kometa, 1995). Several performance aspects are investigated in this regard including time, cost and quality.

A reputation for litigation is a negative aspect of past performance, considered to be an important attribute (Holt *et al.*, 1994), and hence its inclusion in the major survey.

Financial soundness

Perhaps, in every business activity, financial soundness (i.e. stability and status) is one of the most important attributes of a company. One logically considers this aspect when engaging in contracts or business relationships. As an example, in contractor selection (Russell *et al.*, 1992; Russell and Jaselskis, 1992b; Assaf and Jannadi, 1994; Bubshait and Al-Gobali, 1996; Kumaraswamy, 1996; Hatush and Skitmore, 1997a-c; Jennings and Holt, 1998; Ng and Skitmore, 1999; Khosrowshahi, 1999), it is assumed that a financially sound contractor can finish the project on time, on budget and to the quality required. That is, the performance of contractors depends on how they can maintain progress on site and this requires sufficient financial support. This also holds true for architects (ASCE, 2000) and clients (Odusote and Fellows, 1992; Kometa, 1995; Akinci and Fischer, 1998). Kometa (1995) has shown that a client's financial stability will influence consultant performance and therefore project performance. It is also clear that a client's financial stability impacts their ability to pay the engaged contractor and architect. Hence, it is also a useful measure of client performance.

Qualification and experience of personnel

The impact of key personnel on project performance and participant performance is unquestionable. In essence, the literature suggests that personnel attributes should include qualification and experience of the director / principal in the head office and site personnel, i.e. site manager and project architect (*contractor*: Russell and Jaselskis, 1992b; Holt *et al.*, 1994; Kumaraswamy, 1996; Tam and Harris, 1996; Hatush and Skitmore, 1997a-c; Jennings and Holt, 1998; Khosrowshahi, 1999; *architect*: Kasma, 1987; MacNeil, 1997; ASCE, 2000; *client*: Kometa, 1995). The qualification and experience of the client representative plays an important role in determining project as well as client performance (Kometa, 1995; Walker, 1994, 1995, 1998; ASCE, 2000).

Working relationships

It has been suggested that working relationships affect project performance (Diekmann *et al.*, 1994; Cheung, 1998; Chua *et al.*, 1999), and hence may also influence the performance of participants. Dozzi *et al.* (1996), Hatush and Skitmore (1997a-c), Jennings and Holt (1998), Ng and Skitmore (1999), and Khosrowshahi (1999) found this attribute to influence contractor performance. Moreover, a high level of former experience between the client and the contractor has been found to be efficient in reducing conflict on construction projects (Gardiner and Simmons, 1992). While Diekmann *et al.*, (1994) considered the quality of working relationships (i.e. in terms of good to bad continuum) on previous projects, Cheung (1998) emphasized the number of projects both participants have worked together and the quality of the relationship between project personnel. Considering the temporary nature of construction projects (Cherns and Bryant, 1984; Reve and Levitt, 1984; Mohsini, 1989; Mohsini and Davidson, 1992) and the requirement for developing trust between participants (Munn, 1995), previous working relationships (especially at personnel level) are very important if project implementation is to be successful.

Degree of evaluation (of participant) prior to contract award / engagement

Jaselskis and Russell (1992, 1992a, 1992b) advocated that a client's contractor evaluation efforts before award of contract may influence contractor performance. Kometa (1995) suggested that consultants should assess clients on all aspects, and not rely solely on financial measures. Furthermore, ASCE (2000) stated that, in the designer selection process, the designer may benefit from learning as much as possible about the client's history, mission, and capacity to support the project by conducting a thorough reference check. They suggested that the degree of evaluation efforts by a participant, may influence the outcomes that a participant gets out of another. The degree of evaluation is related to project size as Jaselskis and Russell (1992) found that on larger projects, more extensive contractor evaluation effort is expended. They further explained that larger projects tend to have more visibility than smaller ones, and thereby demand more attention.

3.2.4.2 Architect attributes

In the construction process, architects are often appointed as lead designers. Therefore, architects play an important role in determining project performance. The following attributes, identified from literature, are specifically relevant to architects as service providers in the construction industry.

Operational size (in terms of catchment)

Similar to company age, turnover and number of employees, this attribute indicates the size of a company. Operational size represents another measure of company size, that is companies that operate at a national level are likely to be larger than ones that operate at a regional or local level. For example, larger companies have more resources and will normally seek work at a national or possibly international level. This attribute also indicates the firms' mobility potential which would be of particular interest to clients seeking a continuity contract or serial tender where the works may be spread over a large geographic area (Holt *et al.*, 1994).

Methods of selection

Two contrasting methods of architect selection are qualification-based selection (i.e. negotiation) and competitive fee tendering (ASCE, 2000). Other methods such as two-envelope selection are considered to be under the umbrella of competitive tendering since they are sometimes used to help meet the client's short-term financial goals (ASCE, *ibid.*). The ASCE (*ibid.*) recommended qualification-based selection for achieving high project quality because it (i) can secure fully capable and qualified architects to meet project objectives, (ii) allows the client and architect to agree on a fee which is fair and based on the scope of services, and (iii) provides more opportunities to achieve creative solutions to design problems which will ultimately control the project's life-cycle cost and quality. Conversely, competitive fee tendering often does not facilitate good project performance for several reasons including (ASCE, *ibid.*):

- The low bidder may not be fully qualified to perform the services.
- It is rare for an advertised scope of services to contain all the design services required, resulting in amendments to the architect's agreement and variations.
- The nature of the agreement may limit the ability to achieve a 'meeting of minds' (i.e. consensus) on difficult project objectives.
- Contracting on the basis of a limited scope and fee tends to reduce the number of opportunities for alternative studies and evaluation, and also limits the flexibility available to the client and architect in solving problems that may arise as the project proceeds.

- Skimping on design costs often increases the number of variations, misunderstandings, and other unplanned events and reduces the attention paid to operating and maintenance efficiencies, all of which tend to drive up life-cycle costs.

Additionally, given very fierce competition for work, architects may submit lower fee bids leading to poor performance (e.g. unable to complete design / drawings on time due to inadequate resources, additional fees).

Method of selection may also be determined by the amount of risk that the client would be willing to take (Sidwell, 1982). Competitive tendering would involve a high degree of risk, while negotiation based on a fee would involve relatively lower risk (Sidwell, *ibid.*).

Selection criteria

The emphasis of this attribute is on criteria used in architect selection. This was advocated by Cheung (1998) in contractor selection, but also holds true for architect selection (Dean, 1998). An emphasis on design fees can cause similar problems to lowest tender in contractor selection. Other aspects of performance may suffer, such as timely completion of drawings, quality of design, etc. Important selection criteria considered are technical ability, past experience / performance, quality and design flair, third party references / recommendations, fee, and reputation.

Method of payment

There are two common methods of payment to architects, namely cost- or effort-related fees (e.g. percentage cost, hourly or per diem rates, cost plus fixed fee) and lump-sum fees (RIBA, 1994; ASCE, 2000). The main difference being in the allocation of risk between employers and service providers. While the risk of payment method is more apparent to contractors and clients (Akinci and Fischer, 1998), this is also applicable to architects, and hence may impact on their performance. For example, in the case of project overruns, an increase in total project costs does not change fees when using the lump sum method, whereas with the percentage cost method in such instances additional fees would be paid. Moreover, with the lump sum method, there is no incentive to increase total project costs. Both methods require different implementation strategies on behalf of the client and the architect. Ibbs and Ashley (1987) suggested that lump sum contracts can create an adversarial relationship between contracting parties which can lead to disputes. This will increase project costs due to litigation. In a similar vein, Ruff *et al.* (1996) discovered that the extensive use of lump sum contracts in remediation projects had led to a number of disputes, delays, change orders and cost overruns. They further advocated that a flexible payment structure (i.e. cost-plus-fee) is better able to cope with common problems encountered on remediation projects, such as scope changes, budget overruns, delays, disputes and change orders. This suggests that the method of payment may impact performance and satisfaction levels.

In general, cost- or effort-related fees are more appropriate where the services to be performed have not been, or can not be, well defined, whereas lump-sum fees are more appropriate when the scope of services is set without ambiguity by mutual consent of the parties (ASCE, *ibid.*).

Design fees

Design fees may impact architect performance since they represent the designers' primary source of income (McKee, 1993). Since more talented people are normally paid higher than their counterparts, higher design fees could be associated with better architect performance. As a percentage of total project cost, design fees on larger projects are normally less than those on smaller projects (RIBA, 1994).

References

Basically, good references are yielded when architects have performed well on projects leading to satisfied clients. Therefore, references are related to the past performance of architects (Kasma, 1987). References play an important part in the selection and evaluation of architects (Kasma, *ibid.*; McKee, *ibid.*; ASCE, 2000) since their appointments are often based on 'word of mouth' between clients.

Professional membership

Nowadays, architects must be members of appropriate professional organisations (e.g. Royal Institute of British Architects [RIBA]) if they are to obtain the necessary recognition. Membership of the RIBA for example, requires accumulation of professional experience and knowledge in the field and hence demonstrates competency and capability. Professional membership is also one important criterion in architect selection (McKee, 1993, ASCE, *ibid.*).

3.2.4.3 Contractor attributes

Responsible for physically constructing the building and the associated tasks and responsibilities involved, the contractor plays a key role in the construction process. Most architect attributes discussed in section 3.2.4.2 are also relevant to contractors since both act as service providers in the construction industry. Such attributes include operational size (in terms of catchment), methods of selection, selection criteria, method of payment and references. Specific contractor attributes identified from the literature and used in the research are now presented and discussed.

Attributes related to labour and subcontractors / suppliers

Contractor performance is dependent on the persons who actually do the work on site. Contractors should be able to procure the desired quality and quantity of manpower. Directly employed labour may facilitate good on site performance (Russell *et al.*, 1992; Assaf and Jannadi, 1994) because such labour can be easier to manage and may produce higher quality of work when compared with labour only subcontractors (Tam and Harris, 1996). Moreover, it is also common practice for contractors to employ subcontractors for specialist work packages and so forth (Tam and Harris, 1996). Contractors should have good working relationships with their suppliers (Ng and Skitmore, 1999), especially any local ones, to ensure ease of ordering and timely delivery. Adequate knowledge of local labour and subcontractors / suppliers will ensure satisfactory procurement of these resources.

Equipment / plant available

The correct choice and availability of plant is pivotal to effective project execution and therefore contractor performance (Russell *et al.*, 1992; Assaf and Jannadi, 1994; Holt *et al.*, 1994; Bubshait and Al-Gobali, 1996; Kumaraswamy, 1996; Tam and Harris, 1996; Hatush and Skitmore, 1997a-b). Contractors can either own or hire such plant. Generally, equipment availability does not present a major problem, however if specialised equipment is necessary to execute the work, equipment availability can be of high importance (Russell *et al.*, 1992). Similarly, plant would be of greater importance on civil engineering projects where the scale of projects demands high levels of plant utilisation (Holt *et al.*, 1994). Plant ownership could be one source of competitive advantage for contractors and can provide some indication of the contractors' long-term planning policies and attitudes, especially in fostering good relationships with clients (Tam and Harris, 1996).

Health and safety

Health and safety has become an important criterion in assessing contractor performance (Russell *et al.*, 1992; Assaf and Jannadi, 1994; Holt *et al.*, 1994; Dozzi *et al.*, 1996; Hatush and Skitmore, 1997a-c; Ng and Skitmore, 1999; Khosrowshahi, 1999). In the UK, this is partly due to the statutory requirements of the Health and Safety at Work Act 1974 and, the enforcement of the Construction (Design and Management) (CDM) Regulations in 1994 (Holt *et al.*, 1994). Furthermore, accidents cause project delays, extra expense and lead to poor overall project performance. Hence, construction costs can be reduced via the careful selection of safe contractors (Samelson *et al.*, 1981 and Samelson and Levitt, 1982 cited in Hatush and Skitmore, 1997a).

For contractors, the number of accidents reported and the completeness of their health and safety policies provide useful indicators in this regard. Effective health and safety provisions on site can have a positive impact on performance in current and future projects.

Quality assurance / quality control policy

This attribute has been recognised as a criterion for contractor evaluation / selection (Holt *et al.*, 1994; Bubshait and Al-Gobali, 1996; Dozzi *et al.*, 1996; Ng and Skitmore, 1999; Khosrowshahi, 1999). Moreover, contract documents now increasingly include quality assurance standards (e.g. ISO 9000) specifying, for example, building procedures and elaborate inspection requirements (Dozzi *et al.*, 1996). An effective quality control system within an organisation leads to higher quality products. It is also in the contractor's interests to adopt quality assurance programmes for competitive advantage, and improved client satisfaction, productivity and efficiency (Dozzi *et al.*, 1996).

Formal training regime

Employees have been recognised as the most important asset of a company. Moreover, site personnel are pivotal to project performance. A formal training regime will improve the capability of employees (Tam and Harris, 1996). This aspect was considered as an important factor influencing contractor performance (Holt *et al.*, 1994; Tam and Harris, *ibid.*). The implementation of a formal training regime reflects high levels of human resource management, and should help lead to successful project implementation. This may also be associated with companies who are well-established and have better long-term planning policies (Tam and Harris, *ibid.*).

Reputation for claims

Reputation for claims is another criterion used in contractor selection (Assaf and Jannadi, 1994; Ng and Skitmore, 1999). 'Claim conscious' contractors can contribute to project disputes (Kumaraswamy, 1994; Cheung, 1998). Furthermore, Holt *et al.* (1994) suggested that a reputation for claims was associated with a tendency for litigation in which a company with a strong litigation history is possibly experienced at claims and may be classed as having an eye for opportunities to exploit. Due to fierce competition in the construction industry, contractors may often bid lower than the work value in order to win work, and then recover losses via claims (Holt *et al.*, *ibid.*). Hence, some contractors have developed a reputation for submitting claims as a means of generating profit. Such practice damages the image and reputation of the industry and is generally considered unacceptable.

Difference between contract sum and estimated value, and difference between contract sum and next lowest bidder

The estimated value is the client's estimate of the contract sum and is calculated before bidders provide their bids for the project (Assaf *et al.*, 1996). Difference between contract sum and estimated value, and difference between contract sum and next lowest bidder can provide an indication of competition levels and bidding strategies. When competition is severe contractors may be forced to bid extremely low, and performance can sometimes suffer. Often, contractors may submit claims for loss and expense in an attempt to generate additional profit.

3.2.4.4 Client attributes

Clients, as employers of the construction industry, should possess certain attributes necessary to ensure successful implementation of their projects (Kometa, 1995). These attributes will influence their performance on construction projects. The following section discusses the attributes identified from literature.

Attributes related to construction experience

As early as 1965, Higgin and Jessop (1965) categorised clients as either sophisticated or naive clients. Levels of experience will influence the way the client deals with the construction process (Masterman and Gameson, 1994). Masterman and Gameson (*ibid.*) argued that this should not only consider previous experience of building, but also previous experience of a particular type of building. Cheung (1998) advocated that client experience is one factor influencing project dispute resolution and project performance. Experienced clients are more likely to get higher levels of satisfaction than inexperienced clients (Sidwell, 1982; Naoum and Mustapha, 1994). Client experience will also impact project performance (Naoum and Mustapha, *ibid.*) and consequently the performance of contractors and architects, hence its inclusion in this research. Here, the number of similar types of project undertaken by client within the last five years, the presence of a separate construction department, as well as the client's capability (i.e. in-house expertise), project management, project monitoring and experience in quality assurance procedures can provide some indications of this.

Organisational structure and communication channels

Kometa (1995) argued that a client's organisational structure and communication channels may influence the performance of consultants (i.e. architects). It is essential that the client's organisational structure and communication channels be clear in order to ease the flow of information and decision making.

Nature of client business

While there is no evidence to suggest that the nature of a client's business impacts performance, within the context of this research, this attribute categorises clients according to their business nature, i.e. retail, finance, industrial, public, etc. Clients from different business backgrounds may emphasize different needs / objectives (Nahapiet and Nahapiet, 1985; Chinyio, 1999) and strategies to fulfill their needs. This may induce different performance criteria.

3.3 PROJECT ATTRIBUTES

Table 3.4 presents a summary of the project specific attributes found to influence performance as identified from the literature. Using the same criteria presented previously (refer to section 3.2.4), a number of project attributes were selected for inclusion in this research.

Project attributes, which influence performance, can be categorised into controllable and uncontrollable attributes. Controllable attributes are those which can be controlled and amended by adopting appropriate project strategies. Conversely, uncontrollable attributes are considered in this research as those beyond the control of participants or if the participants wish to control them, require fundamental changes and unreasonable amounts of effort. These attributes are described in the following.

3.3.1 Controllable Project Attributes

The following section discusses controllable project attributes, i.e. those that are within the control of participants. Most of these attributes can be controlled during the earlier stages of the construction process, and therefore, knowledge of how they influence performance is necessary, if the project is to be successful.

Procurement route

While the impact of procurement route on performance has been recognised by, to name a few, Sidwell (1982), Ruff *et al.* (1996), Ng and Skitmore (1999), and Tookey *et al.* (2001), it is not the only determinant of project performance (Rowlinson, 1988; Naoum, 1989; Naoum and Mustapha, 1994; Kumaraswamy and Dissanayaka, 1998). The client will choose the procurement route which suits their particular needs and strategies

Table 3.4 Summary of project attributes influencing performance

Project attributes influencing performance / References	Sidwell (1982)	Might and Fischer (1985)	Vlatas (1986)	Jackson (1990)	Jahren and Ashe (1990)	Laufer and Cohenca (1990)	Parfitt and Sanvido (1993)	Diekman *et al.* (1994)	Naoum (1994)	Hartman and Snelgrove (1996)	Ruff *et al.* (1996)	Ibbs (1997)	Pocock *et al.* (1997)	Akinci and Fischer (1998)	Cheung (1998)	Chua *et al.* (1999)
Project characteristics																
Size of project	●	●			●			●						●		●
Type of construction					●											
Pioneer project								●								●
Project complexity	●															
Design complexity								●						●	●	
Construction complexity								●							●	●
Site limitations								●								●
Site location (remoteness)								●								●
Project duration	●															
Project cost	●															
Level of modularization																●
Level of automation																●
Level of skill labour required																●
Contract																
Clear and unambiguous contracts (clarity)										●				●	●	●
Realistic contractual obligations								●							●	●
Risk identification/allocation								●							●	●
Type of contract (method of payment)														●		
Variation (including design changes)												●			●	
External factors																
Environmental issues								●								
Public interference / public issues								●								●
Economic risk / condition	●													●	●	●
Political risk / condition	●													●		●
Permits and regulations (government issues)								●								●
Ground / geological condition														●		
Weather condition														●		
Technological	●															
Major change	●															
Design																
Percentage of design completed prior site work						●										●

Table 3.4 Summary of project attributes influencing performance (cont.)

Project attributes influencing performance / References	Sidwell (1982)	Might and Fischer (1985)	Vlatas (1986)	Jackson (1990)	Jahren and Ashe (1990)	Laufer and Cohenca (1990)	Parfitt and Sanvido (1993)	Diekman *et al.* (1994)	Naoum (1994)	Hartman and Snelgrove (1996)	Ruff *et al.* (1996)	Ibbs (1997)	Pocock *et al.* (1997)	Akinci and Fischer (1998)	Cheung (1998)	Chua *et al.* (1999)
Design time (duration)	●															
Procurement																
Procurement route	●										●					
Factor influencing project buildability																
Degree of interaction between cont. & arch. prior const.			●						●				●			
Process related issues																
Clarity/adequacy of technical specification				●				●								●
Scope definition								●								
Operating procedures								●								
Report updates																●
Budget updates																●
Schedule updates																●
Design control meetings																●
Construction control meetings																●
Degree of managerial control	●															
Site inspections																●
Communication during design and construction																●
Constructability programme																●
Input from all group involved								●								
Financial planning								●								
Functional plans																●
Participants' team turnover																●
Participants' top management support																●

(Kumaraswamy and Dissanayaka, 1998; Tookey *et al.*, 2001). The procurement route adopted may have a fundamental impact on performance. For example, partnering was found to have a positive effect on project performance (Ruff *et al.*, 1996), because of the level of teamwork fostered by this approach which help to improve the commitment and proactive attitudes of all project participants (Latham, 1994; Egan, 1998).

Contract

Contracts are instruments for recording obligations and responsibilities (Cheung, 1998). The terms of contract define how risks are allocated between contracting parties (Akinci and Fischer, 1998). Since project objectives are often expressed in the contracts, the quality of the contracts will have a significant impact on project performance (Cheung, 1998). One measure of a contract's efficiency and effectiveness (i.e. quality) is its ability to clearly assign risks between contracting parties (Hartman and Snelgrove, 1996). It is essential that the contracting parties completely understand the risks they must bear. Unclear and ambiguous contracts, such as in the case of bespoke contracts, may create misunderstanding leading to dispute and subsequent poor performance (Russell and Jaselskis, 1992a; Hartman and Snelgrove, 1996; Akinci and Fischer, 1998). Here, the influence of form of contract (JCT, ICE, NEC, etc.) and the clarity of the form of contract on satisfaction levels were investigated. The clarity of the form of contract measures the relative understanding of participants.

Project duration and cost

Project duration and cost are two common quantifiable measures of project performance. These could be deemed as measures of project size in which Might and Fischer (1985) maintained that, due to higher stakes on larger projects and their consequences of failure, the larger the project, the more likely that monitoring and control practices will be more rigorous. Moreover, in larger projects, more care may be exercised in the bidding and planning process (Jahren and Ashe, 1990). Similarly, in research on construction planning, Faniran *et al.* (1998) indicated that as project complexity increases, more efforts tend to be invested in project control. These therefore, will improve performance and satisfaction levels. However, at the same time, larger projects are generally more complex leading to an increase possibility of cost overrun (Rowland, 1981 cited in Jahren and Ashe, 1990). Moreover, larger projects may have an increased possibility of disputes (Diekmann *et al.*, 1994). Jahren and Ashe (1990) discovered from investigation of 1576 construction projects, that the median cost overrun rate increases as the project size increases. Furthermore, cost overrun rates of 1-11% are more likely to occur on larger projects than smaller ones, however cost overruns greater than 11% mostly occur on smaller projects. They explained that this is possibly because projects become more complex as they become larger leading to the occurrence of larger cost overruns. However, at the same time, on large projects, managers may make special efforts to keep cost-overrun rates from becoming excessively large. Akinci and Fischer (1998) advocated that since it is hard to tell how project size affects cost overrun, design complexity can be used to determine the effect of project size.

Projects in delay or overbudget are indicative of poor project performance and low satisfaction levels. Here, this research investigated the influence of project duration, cost, delay, overbudget on satisfaction levels.

Variations

While some variations are inevitable (Ibbs, 1997), they are all, to some extent, controllable (Akinsola, 1997). It has been recognised that variations hamper project performance (Akinsola *et al.*, 1994; Ibbs, 1997; Cheung, 1998) and contractor performance (Assaf *et al.*, 1996). Akinsola (1997) advocated that the sources of variations are client (choice, forced), designer (choice, defects, brief), management (document, information, contractor) and other (unforeseen, miscellaneous). In this research, variations are investigated in order to determine their relative influence on satisfaction levels.

Project complexity

Project complexity is associated with project size in which larger projects are generally more complex (Jahren and Ashe, 1990). Sidwell (1982) described how project complexity influences performance in that a highly complex project may demand participants which can provide a wider range of services and expertise. Sidwell (*ibid.*) advocated three aspects of project complexity, namely the initial complexity of the problem as posed by the client (the brief), the complexity of the solution to the problem as elaborated by the design team (the design complexity), and the complexity of the production and assembly operations required to implement the design by the builder (technology of the building). He opined that the objective measurement of complexity is not easy, instead some idea of project complexity may be gained by consideration of design time, building time, the ratio of build rate, and project cost.

However, Diekmann *et al.* (1994) suggested that project complexity comprises design and construction complexity which were adopted in this research. As mentioned before, Akinci and Fischer (1998) suggested that design complexity can be used to determine the effect of project size on cost overrun (and hence performance). The initial complexity of the project (i.e. from the brief) as suggested by Sidwell (*ibid.*), is considered as a problem brought by the client which (most likely) can not be altered. In Diekmann *et al.*'s (1994) and Cheung's (1998) researches, design and construction complexity were measured subjectively using a Likert scale. This was also used in this research since the respondents targeted were expert practitioners who were considered to have experience appropriate to judge the degree of complexity.

Interaction between contractor and architect prior to work on site

The separation of design and construction has been recognised as one of the fundamental causes of poor performance within the construction industry (Nam and Tatum, 1992; Puddicombe, 1997). Early interaction between architects and contractors fosters effective levels of buildability, and also allows contractors to be part of the value engineering team, thereby improving performance levels (Vlatas, 1986; Naoum, 1994). Additionally, early interaction enables communication and the development of working relationships. Pocock *et al.* (1997) discovered that such increased interaction leads to improved performance as shown by objective measures of 209 completed projects. Interestingly, projects procured using forms of partnering arrangement showed highest degrees of interaction, and performance was found to be significantly better than on traditionally procured projects (i.e. design-bid-build delivery process and lump sum contract). Russell and Jaselskis (1992b) developed a contractor failure model which included early contractor's project manager involvement as one of the significant variables, indicating that the greater the involvement the lower the probability of contractor failure.

Percentage of design completed prior to work on site

It has been suggested that the percentage of design completed prior to work on site affects contractor performance (Russell and Jaselskis, 1992b) and project performance (Laufer and Cohenca, 1990; Chua *et al.*, 1999). Tight project schedules and overlapping design and construction stages, introduce extra project complexity and additional burdens for both the contractor and the architect, thereby influencing their performance. Laufer and Cohenca (1990) found that the percentage of design completed prior to work on site was one of the two most influential factors affecting construction planning outcomes (the other variable being past construction experience). Their findings show that very low percentages of design completion prior to the start of construction may result in considerable delays. They further implied that, as a result of this, the reduction of project duration and cost that would normally be expected from overlapping the design and construction stages, may not be feasible.

Design time

Sidwell (1982) advocated design time as one of the objective measures of project complexity since one may expect complex projects to take longer to design and to build. Complex projects may demand higher expertise on behalf of the participants involved which, in turn, may influence satisfaction levels. Furthermore, Sidwell (*ibid.*) found some evidence of the relationship between design time and success measures including client satisfaction on cost and time, and percentage overrun on cost and time.

3.3.2 Uncontrollable Project Attributes

These attributes were included in this research in order to assess their impact on performance. Knowledge of the impact of these attributes provides participants with an understanding of their influence on project performance. The attributes are now discussed.

Project characteristics

These attributes include type of project (e.g. new building, refurbishment, extension to existing premises, etc.), type of building (e.g. office, retail, residential, industrial, public, etc.), number of storeys and gross floor area of the building. These attributes are derived from the client brief and should satisfy client's needs. Types of project and building were used to investigate whether there were any differences in satisfaction levels of participants in different types of project and building. Number of storeys and gross floor area indicate project size (Faniran *et al.*, 1998) which is associated with project complexity (Jahren and Ashe, 1990). As argued before, complex and generally larger projects, may demand higher expertise on behalf of the participants involved which, in turn, may influence satisfaction levels.

External project constraints

Russell and Jaselskis (1992b), Holt *et al.* (1994), and Russell and Zhai (1996) acknowledged the influence of external constraints on contractor performance. Moreover, external constraints were also found to affect project performance (Sidwell, 1982; Diekmann *et al.*, 1994; Akinci and Fischer, 1998; Cheung, 1998; Chua *et al.*, 1999). Major external constraints considered are ground conditions, weather conditions, and government regulations (e.g. planning permission).

Unknown or unexpected ground conditions may cause delays whilst (e.g.) permits and/or design approval is sought. Furthermore, unknown ground conditions may require additional activities such as removal and transportation of obstructions. These result in a loss of time and an increase in the actual cost of a project (Akinci and Fischer, 1998). As weather conditions affect construction productivity (Koehn and Brown, 1985), unexpected and abrupt changes in weather can cause delays and increase cost during construction. Akinci and Fischer (1998) suggested that, in evaluating the risk of weather conditions, contractors should not only investigate the probabilities and cost consequences of unfavourable weather conditions but also assess project exposure to the risk of poor weather conditions. If the construction project involves mostly outside work, then the risk of weather conditions becomes higher in which case, contractors should pay more attention to the cost implications of poor weather conditions. Holt *et al.* (1994) argued that the British weather is often able to hamper construction work and can have an adverse effect on progress resulting in client dissatisfaction in time performance. Government regulations may disrupt the execution of a construction project, particularly when it affects the public interest and/or environment. Therefore, all regulatory requirements (e.g. planning permit) and/or environmental impact studies should be identified and followed up before commencement of work on site (Diekmann *et al.*, 1994). In sum, these external project constraints may influence participant performance and satisfaction levels.

Site limitations

The ease of access to site influences project performance (Diekmann *et al.*, 1994; Chua *et al.*, 1999). Sites with restricted access, such as in city centres, require different project execution strategies compared to those with unrestricted access such as those on green field sites. This is particularly important in the procurement of materials and management of the site. Architects should also take into consideration the ease of access to a site in the design process. Improper strategies cause delays and cost overruns, and thereby influence satisfaction levels.

Remoteness (location) of site

Contractors are often appointed based on their home office location, since this is known to impact performance (Russell *et al.*, 1992; Assaf and Jannadi, 1994; Holt *et al.*, 1994; Bubshait and Al-Gobali, 1996; Dozzi *et al.*, 1996; Jennings and Holt, 1998; Alsugair, 1999; Ng and Skitmore, 1999). Site location may also affect project success (Diekmann *et al.*, 1994; Chua *et al.*, 1999). The distance between home office and site contributes to the ease of communication, decision making and control (Holt *et al.*, 1994). One may argue that the use of information technology such as video conferencing, could minimise, if not eliminate, the effect of location. However, utilisation of such advanced technology is still relatively rare in UK construction.

3.4 SUMMARY

A thorough review of literature in the performance domain has identified attributes influencing performance. These attributes have been categorised into participant and project attributes. Participant attributes consist of generic and participant specific attributes. Based on their nature, project attributes were sub-categorised into controllable and uncontrollable attributes. Due to the vast number of attributes identified from the literature, criteria for selecting attributes were developed and applied. The attributes selected for inclusion in this research have been presented and discussed. The next chapter discusses satisfaction attributes used in this research.

Chapter 4

Satisfaction Attributes: A Literature Review

4.1 INTRODUCTION

This chapter introduces the concept of satisfaction. The relationship between performance and satisfaction in the context of the project coalition is explained. Then, the 'frame of reference' concept is introduced. A review of literature on antecedents of satisfaction judgements which serve as a fundamental background for formulation of satisfaction attributes, is presented. Based on these, the underlying (i.e. satisfaction) attributes which may cause two individuals to have different levels of satisfaction concerning a particular project are formulated and discussed.

4.2 SATISFACTION: PSYCHOLOGICAL ISSUES

From the earliest human existence, satisfaction (e.g. in pursuing human needs) has been a main concern of human beings. Satisfaction embraces all aspects of human life. It is evident in the pursuit of this research in many forms, such as personal achievement, recognition and future development. Satisfaction is a complex phenomenon because it concerns psychological issues within the mind of the individual. Understanding of this complex phenomenon may help human beings to achieve the basic quest of being satisfied.

In the construction project domain, satisfaction represents the bottom line of successful project implementation. Previous research has argued that the success of a project was dependent on how the outcomes of that project satisfied the participants involved (Ashley, 1987; Liu and Walker, 1998; Liu, 1999). However, none of this previous research sought to identify the determinants of satisfaction. This may be due to the complex latent nature of the satisfaction phenomenon.

In the context of the project coalition, the satisfaction of each participant is a pre-requisite to the maintenance of harmonious working relationships, which facilitate effective participant performance and project performance. This is mainly due to the interdependencies and interrelationships that exist between those participants as earlier explained (refer to Chapter 2).

To gain an understanding of satisfaction and because of the dearth of such literature in the construction management domain, literature from the fields of applied psychology and marketing research was studied. Although satisfaction in these two domains is concerned with different aspects, such as job satisfaction, satisfaction with consumption and life satisfaction, the processes involved are essentially identical (Oliver, 1997).

Satisfaction is difficult to define and there is no consensus on the definition of satisfaction (Oliver, *ibid.*). Oliver (*ibid.*) suggested that consumer satisfaction has three variants, i.e. satisfaction with individual elements of product and service delivery, final outcome satisfaction and satisfaction with satisfaction (See Figure 4.1). The existence of these variants makes satisfaction difficult to define. Oliver further offered the following definition as being consistent with the theoretical and empirical evidence:

> "Satisfaction is the consumer's fulfillment response. It is a judgement that a product or service feature, or the product or service itself, provided (or providing) pleasurable level of consumption-related fulfillment, including levels of under or overfulfillment."

It was noted that fulfillment and hence a satisfaction judgement involves a comparison between an outcome and a comparison reference.

Satisfaction
with the Complete Consumption Experience

Satisfaction with Events That Happen during Consumption	Satisfaction with Final Outcomes	Satisfaction with Level of Satisfaction Received
Waiting in line Seating comfort Surrounding noise Screen view Previews Concessions Acting Action	Enjoyment Entertainment Enlightenment Excitement Emotional involvement	Inadequate Adequate Excessive

Figure 4.1 Variants of 'satisfaction' (after Oliver, 1997)

Furthermore, Locke (1970), Locke *et al.* (1970), Locke and Latham (1990), and Ilgen and Hamstra (1972) found that satisfaction is a function of comparison between an individual's perception of an outcome and their expectation for that outcome. Here, expectations, primarily defined as predictions about what is likely to happen, are commonly used as a reference against which an individual can compare perceived outcome, i.e. performance (Zeithaml *et al.*, 1993; Walker, 1995). Performance only has meaning if it can be compared to some standard. Oliver (*ibid.*) argued that expectations contain elements which are not tangible and can not be easily quantified. That is, individuals (i.e. assessors) do not simply speculate about whether an outcome will occur, instead, unknowables, uncertainties, probabilities, apprehensions, and even hopes are part of the satisfaction process. Hence, satisfaction levels achieved are dependent on an individual's perceptive thinking. Hence, satisfaction in the context of performance assessment is highly subjective in nature.

4.3 RELATIONSHIP BETWEEN PERFORMANCE AND SATISFACTION IN THE ASSESSMENT OF PERFORMANCE

Figure 4.2 illustrates the relationship between performance and satisfaction in the context of performance assessment. Performance outcomes are the input and levels of satisfaction / dissatisfaction are the output. Between the input and the output, a psychological processing or 'black box' exists. That is, an observer can see only what goes in and what comes out, not what occurs inside (Oliver, *ibid.*). Additionally, this psychological process is subjective and difficult to interpret. Satisfaction is regarded as an internal frame of mind, tied to mental interpretations of performance levels.

The implications for this research are that participants (i.e. performance assessors) will have their own psychological interpretation of the performance of others. Revealing such psychological processing involves complex procedures and research processes as it requires a complete understanding of an assessor's antecedent state at the time of the performance assessment. Such a level of understanding would involve many psychological variables and resource demands, considered beyond the scope of this research. Therefore, for the purposes of this research, satisfaction attributes were formulated based on a literature review of antecedents of satisfaction judgements, relevant for mutual performance assessment within the construction PC. Although the use of such attributes may not reveal the in-depth psychological issues, their utilisation is practical given the time and resource constraints, and may provide an indication of their influence as a basis for further research. It is envisaged that these attributes have a stake in determining an assessor's antecedent state, e.g. expectations.

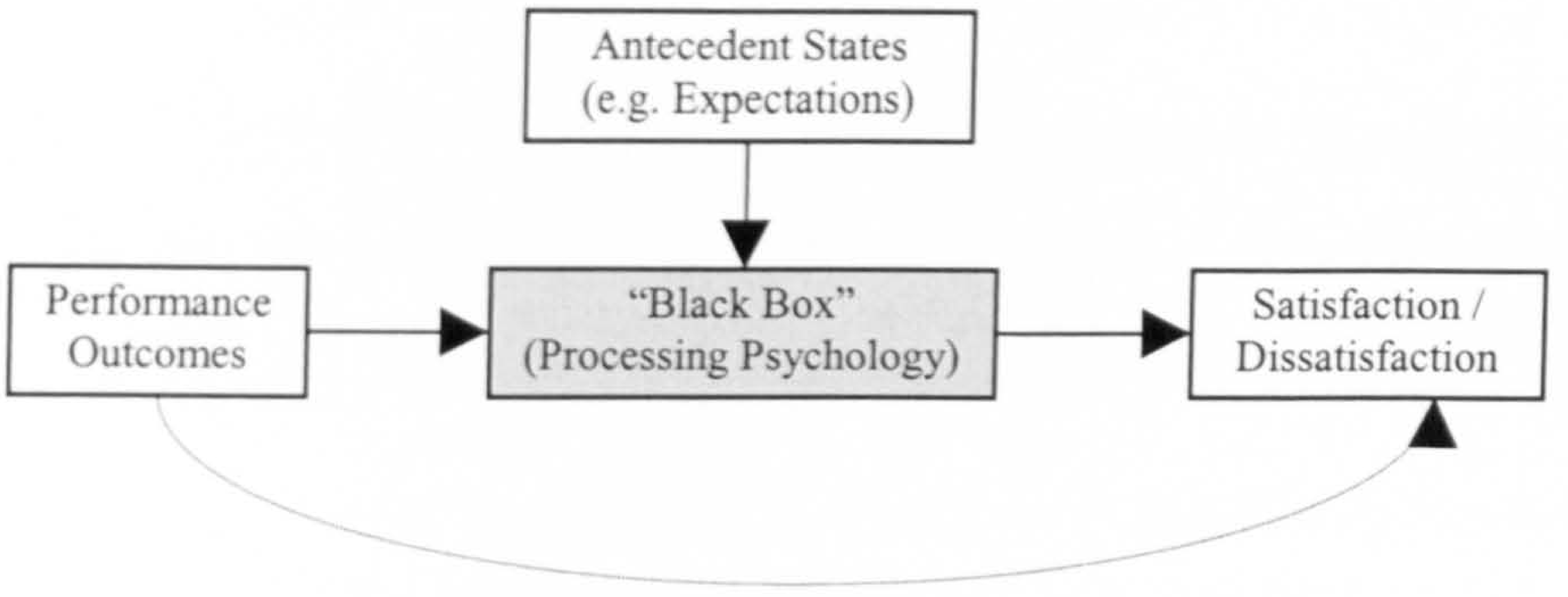

Figure 4.2 A mediated performance model of satisfaction (after Oliver, 1997)

4.3.1 The 'Frame of Reference' Concept

In this context, satisfaction can be specifically defined as a function of the perceived characteristics of a performer in relation to an assessor's frame of reference. Smith *et al.* (1969) argued this concept in the context of worker job satisfaction. They further stated that for given situations, expectations and experiences play important roles in providing the relevant frame of reference. Here, frame of reference is defined as the internal standard (or standards) an assessor uses in making an assessment. What are the standards in making such an assessment? Assessors are likely to have different standards when judging the performance of others. Different persons enter the same objective situation with different frames of reference, which affect both their summary assessment of the situation and the aspects of that situation which are pertinent to their judgements. Better understanding of the judgements made by individuals can be obtained by knowing their frame of reference.

Defining an assessor's frame of reference is considered a very difficult, if not impossible, task to achieve. However, investigating underlying attributes that form an assessor's frame of reference (i.e. antecedents of satisfaction) is somewhat easier. These 'satisfaction' attributes are differentiable from performance attributes mainly due to their unique nature which is inherent within an individual (i.e. assessor). In other words, performance attributes influence both participant and project performance, whereas satisfaction attributes relate to the assessor and influence their own performance assessment. As noted previously, while performance attributes are often considered in the objective assessment of performance, satisfaction attributes are related to the subjective assessment of performance. In this research, performance assessment includes both types of (performance and satisfaction) attributes.

4.4 SATISFACTION ATTRIBUTES

To obtain knowledge and understanding of the 'psychological' aspect of satisfaction, literature in the field of marketing research, where research on satisfaction processes and antecedents of satisfaction is abundant, was reviewed. Here, the research concerns consumer satisfaction with products or services. One may question the relevance of using marketing research concepts in the project coalition setting. However, the formation of a satisfaction judgement (i.e. satisfaction process) is fundamentally similar in both fields (Oliver, 1997). Furthermore, in this research, a participant as an assessor (e.g. client) is analogous to a consumer of services in which they evaluate the other two participants' (e.g. architect and contractor) performance.

Based on this, satisfaction attributes were formulated and applied here, in the context of mutual performance assessment within the construction PC. Several conditions necessary for practical application and constraints are explained, followed by a list of satisfaction attributes.

4.4.1 Literature Review on Antecedents of Satisfaction

Early researchers in the area of satisfaction agreed that satisfaction is a function of an initial standard and perceived discrepancy from that initial standard. Specifically, (predictive) expectations are thought to create a primary reference about which an individual makes a comparative judgement (Oliver, 1980; 1997). Oliver (1997) claimed that the expectancy disconfirmation model of consumer satisfaction is the dominant theoretical paradigm in many satisfaction fields. Expectancy disconfirmation involves a comparison of performance observations and subsequent judgement of the degree of discrepancy (i.e. disconfirmation). Other reference points, including needs, ideals, fairness and events that might have been (i.e. regret), although possibly having some influence on the satisfaction process, are not as popular and have not been elaborated in the literature to the same extent, as expectation. Moreover, Oliver (1997) opined that although a number of references can be used in satisfaction judgements, all are channeled into expectations.

Helson (1959) cited in Oliver (1980) argued that in the satisfaction judgement, levels of expectation can be regarded as adaptation levels. Here, expectations are influenced by three factors, namely (i) the product itself including the individual's prior experience, brand connotations, and symbolic elements, (ii) the context including the content of communications from salespeople and social referents, and (iii) individual characteristics including persuasibility and perceptual distortion.

Woodruff *et al.* (1983) and Cadotte *et al.* (1987) challenged the utilisation of expectations as the only standard for comparing perceived performance in satisfaction processes. They opined that expectations can not be ruled out as a possible standard, but that this is not the only standard consumers use. Here, the experience-based norms concept appears to offer an alternative for examining how consumers form satisfaction judgements. They argued that prior experience with another brand provides the standards that can be used to evaluate performance. Specifically, breadth of experience may cause consumers to form norms or standards that establish what a focal brand should be able to achieve. Consumers' prior experiences may bias their perceptions of brand performance. Here, it is assumed that the consumer has experience with various brands of the product. For example, in the context of the construction PC, a client may evaluate the performance of a contractor based on the past performance of contractors with whom they have worked. This was further confirmed by Brown and Swartz (1989) in research on medical service quality which concerned the relationships between patients and physicians. They stated that individuals will compare his/her current service experience with some set of expectations which may be based, in part or in total, on past relevant experiences.

Johnson and Fornell (1991) proposed a framework which incorporates the key factors identified in satisfaction research as shown in Figure 4.3. The primary antecedents of perceived satisfaction are expectations and perceived performance which are viewed as directly influencing satisfaction. They further claimed that individual and product category differences influence satisfaction via expectations and/or perceived performance. That is, expectations and perceived performance mediate the effect of individual and product category differences on satisfaction judgements. Satisfaction has a number of behavioural consequences such as repeat work, which reflects latent satisfaction.

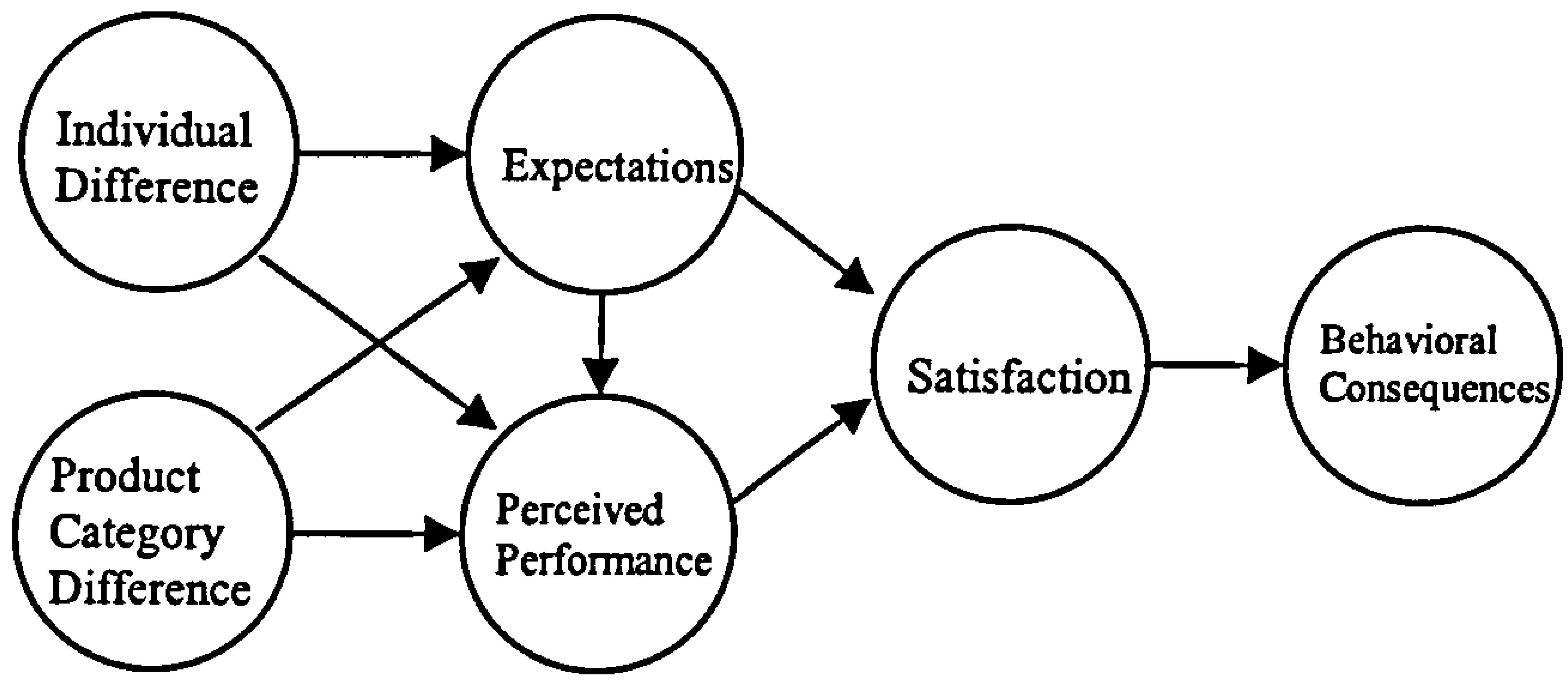

Figure 4.3 A framework for satisfaction research (after Johnson and Fornell, 1991)

Johnson and Fornell (*ibid.*) argued that, in a dynamic perspective, customers' experience with products and services should result in a general increase in perceived satisfaction. It was reported that satisfaction increases with age (Pickle and Bruce, 1972 cited in Johnson and Fornell, *ibid.*). That is, older customers being more pessimistic (i.e. holding lower expectations) and/or tend to judge products or services more positively. In a similar vein, different product categories are assessed with different expectations and perceived performance in mind. In sum, they concluded that expectations and perceived performance indirectly capture any salient individual or product category differences, and therefore, if expectations and perceived performance (i.e. satisfaction levels) are assessed, individual and product category differences are implicitly captured. Particularly, they opined that customer's prior experience with products or services as being a major individual dimension affecting satisfaction judgements. The more experience accumulated, the more likely an individual is to be satisfied with repeated consumption.

Construction is regarded as a service industry since clients purchase a capacity to produce and not a product (Winch *et al.*, 1998). For satisfaction with services which are characterised by intangibility, heterogeneity, inseparability and perishability, Jayanti and

Jackson (1991) empirically found that the individual differences model performed better than the disconfirmation and performance models, in explaining satisfaction judgements. The individual difference model takes into account the impact of individual differences on satisfaction judgements. That is, satisfaction with services is primarily a function of the consumer alone. In their research, individual difference variables investigated were perceived risk of the service, consumer involvement, and consumer innovativeness. Involvement and innovativeness are positively related to satisfaction whereas perceived risk is negatively related to satisfaction. Specifically, involvement seems to have the strongest impact on satisfaction which suggests that highly involved consumers tend to experience higher levels of satisfaction due to the propensity to acquire more information. In sum, this finding suggests that individual consumer characteristics play an important role in satisfaction judgements.

In an exploratory focus group research, Zeithaml *et al.* (1993) discovered past performance as one determinant of customer expectations of service. Other determinants included explicit and implicit service promises, word of mouth, enduring service intensifiers, personal needs, transitory service intensifiers, perceived service alternatives, self-perceived service role and situational factors (e.g. bad weather, catastrophe). However, more research is needed to confirm the relative importance of those determinants. This suggests that past performance (i.e. prior experience) influences satisfaction judgements.

In a thorough review of satisfaction literature, Oliver (1997) concluded that sources of reference in the expectation formation can be grouped into two, namely external and internal sources. The external sources include the following:

- Promotional claims

  Promotional claims are mainly in the form of advertisements and sales statements which mostly represent corporate communication of products or services. It has been shown that advertising may largely be used to form expectations when consumers have no other information sources or prior experiences. Moreover, it has been acknowledged that consumers believe the manufactures' and providers' claims which are used to create expectations of the products' likely performance.

- Word of mouth

  Word of mouth is an important source of information. Experiences of others are largely valued because of similarity between recipient and communicator and lack of a financial motive on the part of the communicator. Moreover, the importance of the information is also dependent on the closeness between the communicator and the recipient. For example, spouses' opinions are more important than those of relatives which, in turn, are more important that those of friends.

- Third-party information

  Third-party information, such as independent reports, journals, magazines and government testing, are often used as sources of information in expectation formation.

- Product cues

  Product cues provide 'hints' of the likely performance of products and services. Product cues that have received much attention in the literature are price, scarcity, brand name, store image, and advertising. For example, higher price has been analogous with better quality. Product scarcity has been analogous with higher value, quality and generally higher price (e.g. antiques, art works). Famous brand names, for example Coca Cola, IBM, Ferrari, connote higher quality and also price. Similarly, consumers generalise the quality of a store's goods from its reputation for fineness, for example Marks and Spencer, and Harrods. Producers of higher quality goods will gain greater benefits from advertising because consumers will learn the product through such advertising, use the product, realise the quality of the product, and then encourage others to use it.

The consumer's past experience and stored information, as internal sources of reference, play an important, but somewhat intuitive, role in expectation formation. This requires examination of the retrieval mechanisms from memory which are used by consumers in expectation formation. This process is subject to distortion and to specific strategies to conserve mental effort including ease of recall and vividness of the event being recalled which are explained in the following:

- Ease of recall

  Ease of recall is mostly dependent on the importance of the product category and the availability of information in the memory. Consumers will not put a great amount of cognitive effort in thinking about an unimportant product. Consumers will access the most immediate information available in the memory and update the past experience with the most recent experience. In a model of expectation formation, prior satisfaction has been found to exert a larger influence on expectation formation than store image and word of mouth. Dissatisfaction experience (i.e. negative events) are more available in memory than satisfaction experience.

- Vividness of recall

  The vividness or distinctiveness of events which have occurred, facilitate cognitive retrieval mechanisms. Here, negative (e.g. dissatisfaction) and surprising events are more distinct than positive and planned events.

Further, Oliver (1997) opined that numerous other influences are known to influence expectation directly or to influence the cognitive retrieval of information from memory suggesting the complexity of studying expectations (and hence satisfaction) in actual consumer environments.

4.4.2 Formulation of Satisfaction Attributes

Antecedents of satisfaction have been identified with particular reference to consumption of products (i.e. goods) and services in marketing research. However, only some of these are relevant and can be practically applied to this research. The reasons are mainly two fold. First, the nature of those antecedents identified is different to those experienced in the execution of construction projects, both in terms of frequency and duration. Furthermore, some are more conceptual and related to marketing for example using external company communications to consumers to help shape expectations (e.g. Parasuraman *et al.*, 1985). Secondly, the research instruments used in this research (i.e. questionnaires) do not facilitate deeper analysis (Fellows and Liu, 1997) and therefore, rule out some antecedents for which acquisition requires deeper data collection methods. Often research in applied psychology and marketing requires deeper data collection methods and hence 'heavy' respondent involvement, i.e. in the form of focus group interviews and laboratory settings, etc. These methods demand substantial time and resources which are considered beyond the scope of this research. Based on these reasons, some antecedents were excluded for further consideration as satisfaction attributes.

Literature on antecedents of satisfaction suggests that prior experience and individual (i.e. assessor) characteristics influence satisfaction judgements. Prior experience and individual characteristics are considered relevant and practical for this research, and serve as useful antecedents of reference points to judge perceived performance. However, they are considered abstract concepts and have to be interpreted / translated into lower / operational concepts in order to enable them to be used in this research as satisfaction attributes. These attributes should be able to capture the prior experience and individual characteristics of the assessor. These specific attributes were identified from the literature on antecedents of satisfaction and then developed based on the author's interpretation, reasoning and judgement, and subsequently verified during interviews and through a pilot survey of practitioners. The following sections present the list of satisfaction attributes in the context of the assessor and the assessor's employer (i.e. company).

4.4.3 Satisfaction Attributes of the Assessor

In the context of this research, the assessor is considered the respondent to the main questionnaire survey (refer to Chapter 6). These attributes are mainly concerned with their individual background (characteristics), experience and perception of other participants.

Experience

This embraces the assessors' experience, in terms of their time spent working in the industry and with their present employer. Moreover, experience with similar types of project is also considered. Experience may influence an assessor's satisfaction judgement in two ways. The greater an assessors' experience, the more standards / alternatives that assessor will have for comparing the current performance. Secondly, an assessor with little experience may have higher expectations (e.g. a graduate working in the industry).

Arditi and Gunaydin (1999) found differences in the perceptions of entry-level professionals and long-time practitioners with regard to process quality in building projects. They argued that these were because of the differences in the respondents' background, expectations and experience. This supports the utilisation of these variables where levels of experience may influence satisfaction judgements.

Vocational background

In an investigation of occupational stereotypes and bias in construction management research, Loosemore and Tan (2000) argued that a respondent from a certain occupational group (e.g. architect, engineer, quantity surveyor, contractor) holds stereotype views which influence the way they perceive others from different occupational groups. They discovered that the relationships among architects, engineers, quantity surveyor and contractors, have significant potential for occupational bias, albeit of a different nature (positive or negative) and to differing degrees. Specifically, the contractor was found to have most cause for negative relationships with other project participants, particularly architects. This suggests that ones vocational background may influence (i.e. performance) judgement. Despite occupational stereotypes, respondents from a certain occupational group may emphasise a particular aspect of performance, for example, quantity surveyors may emphasize cost / financial aspects of performance, whereas architects may emphasize quality aspects. Such biases may manifest in their assessment of the other participants' performance. Consequently, this may influence their level of satisfaction.

Perceptions: general satisfaction levels derived from the project and from the performance of the other participants

These satisfaction attributes measure an assessor's perceived level of satisfaction and perceived level of participant performance in general. It has been shown that prior experience with another brand provides standards that can be used to evaluate performance

(Woodruff *et al.*, 1983; Cadotte *et al.*, 1987; Zeithaml *et al.*, 1993). Furthermore, prior satisfaction has been found to influence expectation formation (Oliver, 1997). The attributes capture an assessor's perceptions based on their experience in working on projects and with other participants. They provide a relative comparison of satisfaction based on the 'case project' (refer to Chapter 6) and with that experienced on other projects.

Perceptions: image of participants

These satisfaction attributes, representing the individual characteristics of the assessor, consider the perceived images of other participants. Such perceptions are based on the assessors' experiences in regard to the common performance and/or behaviour attributed to a particular participant. Such perceptions are presumed to influence their judgement of performance. Here, emphasis was given to negative 'perceptions' which were suggested to exert more influence on satisfaction judgements (Oliver, 1997). For example, perceptions of clients could include 'do not know what they want', 'always changing their mind', 'remote from construction process', 'never pay on time', 'do not listen to alternative ideas', 'always want to minimise cost without considering quality', and 'tend to be influenced by their initial advisors (e.g. QS, architect)'. These were developed from the author's knowledge of the industry, discussions and interviews with practitioners, and from implicit information gained from the literature. For example, Goodacre *et al.* (1982), NEDO (1978, 1988) cited in Masterman and Gameson (1994) suggested that the perception of clients, particularly inexperienced ones, may be considerably influenced by their first point of contact with the construction industry. Here, architects are often the first point of contact for inexperienced clients.

4.4.4 Satisfaction Attributes of the Company

This section presents the satisfaction attributes of an assessor's employer, which may influence that assessor's satisfaction judgement in the performance assessment. Some of these satisfaction attributes were also considered as generic participant performance attributes, such as company age, annual turnover, number of employees (see section 3.2.4.1). However, they are also relevant in this context.

Company age

This attribute indicates how long the company has been in business. It was reported that age influences satisfaction judgement (Pickle and Bruce, 1972 cited in Johnson and Fornell, 1991). Moreover, company age is indicative of experience in undertaking construction projects.

Annual turnover

This is regarded as a measure of company size. Assessors working in large companies (i.e. with higher annual turnovers) may have higher expectations than those working in smaller ones, resulting in lower levels of satisfaction. Moreover, larger companies may have more experience and resources available.

Number of employees

Like annual turnover, this is a measure of company size. Hence, the same implications as those previously discussed apply.

Experience

This investigates the experience of an assessor's employer in undertaking building works. This covers total annual building works, in terms of number and value of projects, and the number of similar projects undertaken.

Nature of business (for client assessor/respondent)

This attribute captures individual characteristics of the assessor. Chinyio (1999) indicated that nature of business (i.e. personality) plays a major role in shaping client values. Hence, in this research, it is envisaged that a client's nature of business may influence their expectations and, hence satisfaction levels.

4.5 SUMMARY

Satisfaction is regarded as an important aspect of life. In construction, satisfaction plays a crucial role in determining the perceived success of a project. More importantly, the levels of satisfaction derived by each participant determine the quality of working relationships between participants in the construction PC. Harmonious working relationships are pre-requisite to good participant and project performance. The relationship between performance and satisfaction in the context of performance assessment is not straightforward, but involves psychological processing which is determined by an antecedent state, e.g. expectation. Here, the outcome of performance assessment (i.e. satisfaction / dissatisfaction) is dependent on the assessor's antecedents of satisfaction. To explore the antecedents of satisfaction, a review of literature in the field of marketing research was conducted. The literature suggested numerous possible antecedents of satisfaction, however only some of these were relevant and practical for this research. These antecedents were prior experience and individual characteristics of the assessor which should be interpreted as several satisfaction attributes which, in turn, should be able to capture the essence of these antecedents. The satisfaction attributes presented influence satisfaction judgement in performance assessment. That is, they help to form an assessor's level of expectation. These attributes were categorised into assessor and company assessor attributes. The attributes identified may not be exhaustive. Other unforeseen and/or unidentified attributes may exert their influence on performance assessment. However, the attributes presented are deemed to represent those which help to form an assessor's frame of reference, and provide an indication of their influence in satisfaction judgement as a basis for further research. The following chapter describes the interview procedures used to identify the performance criteria and confirm the performance attributes identified from the literature.

Chapter 5

Interviews with Practitioners

5.1 INTRODUCTION

This chapter describes the interviews that were conducted to identify the performance criteria[1] and performance attributes[2] of each participant. First, background information and justification of the use of interviews is presented. Then, details of the interviews are presented including the interviewees, interview method and questions put forward. Prior to presentation of the results, the method of analysis is described. Then, the utilisation of multivariant criteria for performance assessment is described.

5.2 BACKGROUND TO INTERVIEWS

One of the critical steps of this research was to determine the performance criteria and performance attributes of each coalition participant. Literature in the domain of performance provides extensive performance attributes as identified in Chapter 3. However, there is very scant literature concerning performance criteria, and that which does exist is rather sporadic in that it concerns only certain participants of the PC, and often focuses on certain criteria only (i.e. lack of comprehensiveness). Therefore, the primary focus of the interviews was to generate an authoritative list of performance criteria for each participant based on the views of the other two participants. Additionally, performance attributes were also sought. In this respect, the purpose was to confirm and add to those performance attributes identified from the literature, based on the considered

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[1] A set of criteria used to measure the performance of a particular participant.
[2] A set of characteristics representing the nature of a particular participant.

opinions of expert practitioners.

5.2.1 Justification of the Use of Interview

In marketing research, Oliver (1997) documented three general approaches in determining a list of performance criteria, i.e. i) broad-based general principles, ii) standard categories and lists, and iii) consumer-generated lists. He argued that the third approach was the most common technique used to determine key performance dimensions (i.e. criteria). This approach involves asking consumers to comment on products. The comments are summarised, coded and interpreted by the researcher and are then used to define the key performance criteria of the product or service. This technique is largely qualitative, but useful (Oliver, *ibid.*). Finally, Oliver (*ibid.*) recommended that, in cases, where little other basis for discovering performance criteria is available (as in this research), this approach is recommended.

Stemming from this principle, interviews were chosen as a means to identify the performance criteria of the three PC participants. Interviews were considered the most appropriate way to gain a thorough understanding of each participant's performance criteria. Interviews allow the exploration of feeling and other subjective / intuitive factors, essential in the evaluation of performance. Interviews also provide sufficient depth to explore value and belief.

The interviews conducted were considered to share similar characteristics to 'focus group' interviews. These allow in-depth exploration of a topic about which little is known (Stewart and Shamdasani, 1990). Krippendorf (1980) distinguished two types of data;

emic and etic data.[3] 'Focus group' interviews provide data, which are closer to the emic side of the continuum because they allow individuals to respond in their own words (Stewart and Shamdasani, *ibid.*). Overall, this research can be considered as moving along this continuum, from emic to etic data. That is, such (emic and epic) data complements and serves to compensate for the limitations of the other (Stewart and Shamdasani, *ibid.*). Furthermore, Stewart and Shamdasani (*ibid.*) contended that 'focus group' interviews are often a useful starting point for the design of survey questionnaires because they provide a means for exploring the ways potential respondents talk about objects and events, for identifying alternatives for closed-ended survey items, and for determining the suitability of various types of scaling approaches. Thus, interviews were considered an essential part of this research.

Since the level of satisfaction derived by one participant from the performance of other(s) participants is dependent on opinion, the performance criteria of each participant (e.g. contractor) were sought from the views of the other two participants (e.g. client and architect). Additionally, interviews also revealed several attributes which respondents felt influenced the outcome of a project and satisfaction / dissatisfaction feelings.

5.2.2 Method of Contacting Interviewees

Targeting the directors / executives of architects, contractors and clients, potential interviewees were initially contacted by letter and presented with an overview of the

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[3] Emic data are data that arise in a natural or indigenous form. They are only minimally imposed by the researcher or the research setting. Etic data, on the other hand, represent the researcher's imposed view of the situation. Little of the research that is actually carried out can be described as completely etic or emic, but it is perhaps more useful to think of a continuum of research, with some methods lying closer to the emic side of the continuum and some techniques lying closer to the etic side (Krippendorf, 1980 cited in Stewart and Shamdasani, 1990).

research (refer to Appendix A1). Respondents were asked to indicate their willingness to contribute to the research, and where appropriate, to appoint a suitable person within the organisation who would be willing to be interviewed.

A *reply form*, and *self-addressed envelope* were enclosed for the convenience of the respondent. The reply form required the recipient to indicate the name and address of the company, name and address of a contact person, and preferred interview appointment. Where two or more companies indicated the same appointment, alternative arrangements were made at the convenience of the interviewees.

5.2.3 Interview Method

In the first instance, the interviewees were asked to describe their company and the nature of projects undertaken. Then a discussion relevant to the subject area followed (refer to section 5.2.4). Interviews were recorded using a 'dictaphone.' In order to ensure frank, honest and fluent discussion, the interviewees were informed that the recordings were to remain confidential and for research purposes only. The interviewer gave assurances regarding the anonymity of participants. On average the interviews lasted one hour depending on the interviewees response and time available.

5.2.4 Interview Questions

The interviews were semi-structured, and involved asking the interviewees three specific questions in connection with the research. These questions were:

1. What criteria do you usually use to assess the performance of the other coalition participants (i.e. contractor and architect, or contractor and client, or client and architect)?

2. In the context of the project coalition, what level of performance do you require from the other participants in order to allow you to perform?
3. What are the performance attributes of the other two participants?

While the first and second questions were related to performance criteria, the third question was related to performance attributes. Additionally and as was considered necessary, supplementary questions were used to probe and obtain further details and to pursue interesting aspects as recommended by Fellows and Liu (1997). During the interview, interviewees were also asked whether they conducted any formal assessment of participant performance. In such cases, a copy of the assessment form was also obtained, hence providing further data. Subsequently the interviews were transcribed for analysis purposes.

5.2.5 Interviewees

As practitioners of the construction industry, the interviewees were employees of project coalition firms, i.e. either clients, contractors or architects. They are project managers, contract managers and project architects or principals / directors of architectural practices.

Client interviewees were experienced UK private and public clients, defined as those who regularly procure construction works from the industry. Private clients were identified from the listing of Key British Enterprises (Dun and Bradstreet, 1998) representing the top UK retailers, while public clients were represented by local authorities or City Councils identified from the Municipal Year Book (Lauren Hill (*ed.*), 1999). Ten private clients and two public clients were interviewed. Hence the views expressed can be considered those of a small sample of experienced clients.

Contractor interviewees were identified from the listing of Key British Enterprises (Dun and Bradstreet, 1998) representing the top UK contractors. Nine contractors were interviewed. The views expressed can be considered those of a small sample of experienced UK contractors.

Architect interviewees were chosen from the list of top UK architects (Knutt and Osborne, 1998). Of the nineteen architects interviewed, the majority were currently handling major UK and overseas building projects, and were qualified architects (i.e. RIBA) at project and top management levels. Their opinions represent the views of a small sample of experienced UK architects.

All interviewees were considered to have a reasonable understanding of the performance of the other participants within the construction process and their views were considered those of 'expert' practitioners.

5.2.6 Method of Analysis

Data was analysed using the principle of the content analysis technique. Neuman (1997) described content analysis as a technique for gathering and analysing the content of text. Here, content refers to words, meanings, pictures, symbols, ideas, themes, or any message that can be communicated and interpreted. Content analysis extracts and categorises the information from the text (Simister, 1994). The analysis captured the content of the transcribed interviews mainly in terms of words and ideas on what criteria were considered most important to participants in terms of the feelings of satisfaction and dissatisfaction. These words and ideas were subsequently categorised into phrases or words representing an appropriate measure of performance.

Neuman (*ibid.*) also argued that content analysis is nonreactive because the process of placing words, messages, or symbols in a text to communicate to a reader or receiver occurs without influence from the researcher. That is, when interviews were conducted, the respondents had no prior knowledge of the subsequent content analysis. Moreover, the interviews were conducted with care, allowing the respondents to express their feelings. This ensured minimum bias, on behalf of the researcher. Notwithstanding this, it was acknowledged that the respondents might introduce bias in their opinions since the research sort to include subjective as well as objective measures. Any ambiguity in the response was addressed through further questioning, thereby addressing any confusion as it arose. This also minimised the problems of reliability and validity. These two issues are worthy of specific consideration.

5.2.6.1 Reliability and validity of interview data

Reliability refers to the degree of consistency with which instances are assigned to the same category by different observers or by the same observer on different occasions (Hammersley, 1992a, 67 cited in Silverman, 1993). Validity refers to the extent that a variable measures or represents what the researcher intends it to measure (Weber, 1990). That is, in content analysis, reliability and validity problems stem from the ambiguity of word meanings, category definitions, or other coding rules (Weber, *ibid.*).

Weber (*ibid.*) advocated that the best content analysis research should combine both qualitative and quantitative analysis of the text. In qualitative analysis, such as applied in this research, Silverman (*ibid.*) argued that authenticity rather than reliability (which is a central methodological issue for quantitative researchers) is often the more applicable issue. The emphasis of authenticity is to gather a thorough understanding of people's experiences. Here, the ultimate aim was to understand practitioners' experience in terms of their satisfaction / dissatisfaction feelings, and then to identify criteria in relation to those feelings. The issue of authenticity is also the reason that qualitative studies are often conducted with small samples (Silverman, *ibid.*).

5.2.6.2 Coding system applied

Weber (*ibid.*) contended that there is no simple right way to conduct content analysis. Instead researchers must judge what methods are most appropriate. Therefore, content analysis should be tailored to the research aim. In content analysis, there are four characteristics of text content, i.e. frequency, direction, intensity and space (Neuman, 1997). Here, the coding system adopted was frequency, i.e. counting the occurrence of the same words / ideas in all interviews. Since the primary purpose of the analysis was to identify performance measures related to satisfaction / dissatisfaction feelings, other characteristics were considered irrelevant and subsequently ignored. The unit of analysis used is the respondent. That is, for a particular criterion, the analysis counts how many respondents deem that criterion important in contributing to their feelings of satisfaction or dissatisfaction.

5.3 RESULTS OF THE INTERVIEWS

This section presents and discusses the results of the interviews. Forty interviews with 'expert' practitioners employed by contractors, architects or clients were conducted. The results are divided into two sections, i.e. performance criteria and performance attributes.

5.3.1 Performance Criteria

The performance criteria for each participant were sought from the opinions of the other two participants. The criteria identified for each participant are now presented.

5.3.1.1 Contractor performance criteria

Tables 5.1 and 5.2 show the key contractor performance criteria identified from interviews with architects and clients respectively. The second column of the tables displays the criteria and the following columns represent the views expressed by architects and clients during interviews. The first column exhibits the ranks of those criteria according to frequency, however, the emphasis here is on how architects and clients consider contractor performance. These criteria were categorised under several main headings and a description of these now follows.

Time, cost and quality: the principal criteria

Overall, time, cost and quality remain the most important and commonly applied criteria in the assessment of contractor performance. These criteria stem from the client's objectives in undertaking any construction project, as derived from client needs. Adherence to schedule (time performance) is ranked highest by both clients and architects. It is worth noting that 'quality' came third after cost in the clients' perception. Perhaps, this is because in the business environment, decisions are always made based on time and cost certainty.

Architects put less emphasis on cost performance (ranked fifth), whereas quality was ranked second. Architects' perception of quality may be affected by the nature of architectural work, which puts more emphasis on quality. In this instance, architects expect

Table 5.1 Summary of architects' perceptions of key contractor performance criteria

RANK	CONTRACTOR PERFORMANCE CRITERIA	ARCHITECTS' RESPONSES																			TOTAL
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1	Adherence to schedule (time performance)		●		●	●	●	●		●	●		●	●	●		●	●			12
2	Quality and standard workmanship	●			●			●		●			●	●		●	●	●	●	●	11
3	Co-operative attitude / team work			●	●	●		●		●					●	●	●				8
3	Proactive in problem solving (to look ahead)			●		●	●	●	●	●					●		●				8
4	Adherence to budget (cost performance)				●			●		●					●		●	●			6
5	Health and safety performance and management						●	●			●						●			●	5
5	Avoidance of claims (not claims conscious)				●									●	●		●			●	5
5	Listening to and understanding problem of others		●	●			●												●	●	5
5	Communication							●	●	●							●		●		5
6	Trust / openness / honesty						●	●											●	●	4
6	To help the architects' work (dev. of design drawings, etc.)		●		●		●												●		4
7	Management / control / co-ordination of workers or subs.							●					●				●				3
7	Quality of site personnel	●						●									●				3
7	Site management			●				●				●									3
8	Feeling on how things went / how well (ease of delivery)				●							●									2
8	Resource management (availability, quality and quantity)							●				●									2
8	Completion of defects					●		●													2
9	Keep informed / share information						●														1
9	Ability to do the work															●					1
9	Well organised													●							1
9	Correct skills											●									1
9	Commitment of key personnel											●									1
9	Site tidiness										●										1
9	Dealing with variations (flexibility and responsibility)							●													1
9	Completion of O & M manual							●													1

Table 5.2 Summary of clients' perceptions of key contractor performance criteria

RANK	CONTRACTOR PERFORMANCE CRITERIA	CLIENTS' RESPONSES												TOTAL
		1	2	3	4	5	6	7	8	9	10	11	12	
1	Adherence to schedule (time performance)	●	●	●	●		●	●	●	●	●	●	●	11
2	Adherence to budget (cost performance)	●	●	●	●		●	●	●	●		●		9
3	Quality of end product				●	●	●	●	●		●	●	●	8
4	Co-operative attitude/working relationship/team work	●			●	●	●	●			●			6
4	Health and safety performance /management	●		●					●		●	●	●	6
5	Site management and control			●	●		●					●	●	5
6	Proactive to problem (to look ahead)			●		●	●						●	4
6	Communication	●	●				●						●	4
6	Avoidance of claims (not claims conscious)		●	●							●		●	4
7	Customer care / focus		●		●	●								3
7	Quality of site personnel						●			●		●		3
7	Completion of defects										●	●	●	3
7	Subcontractor supervision / management			●							●		●	3
7	Ease of delivery (general feeling on how cont. performs)	●			●					●				3
7	Ease / speed of settlement of final account										●	●	●	3
8	Keep client informed	●		●										2
8	Responsiveness to client										●		●	2
8	Planning											●	●	2
8	Trust / honesty		●									●		2
8	Attending variations / changes										●	●		2
8	Compliance to regulations										●		●	2
8	Smoothness of operation and hand-over		●		●									2
9	First interview and presentation					●								1
9	Help develop brief	●												1
9	Understanding contract and specifications											●		1
9	Understanding the cost of their recommendation	●												1
9	Site cleanliness			●										1
9	Contribution to design and buildability					●								1
9	Administration											●		1
9	Method statement												●	1
9	Quality of hand over document (O&M, H&S)												●	1

contractors to deliver the designed architecture to the quality set out in the drawings and specifications.

Attitude of contractor

While the criteria under this heading are subjective, almost all architects and clients use such criteria for assessing contractor performance, suggesting that existing approaches are highly intuitive. In essence, although these criteria are often not explicitly written, they may have a tremendous impact on the satisfaction / dissatisfaction of participants and, frequently, determine the quality of working relationships. Such criteria include teamwork / spirit of co-operation, ability to look ahead and be pro-active, avoidance of claims, listening to and understanding the problems of others, trust / openness / honesty, communication, understand the cost of recommendations, and the sharing of information.

Site and resource management

Criteria under this heading represent the criteria commonly used in the assessment of actual project execution (Assaf *et al.*, 1996) and contribute directly to the achievement of the principal criteria (i.e. time, cost and quality). Such criteria have been the subject of much previous research in the performance domain and hence their relevance to this research (e.g. refer to Assaf and Jannadi, 1994; Holt, 1995; Sawacha *et al.*, 1999). These include health and safety performance / management; capability of site personnel; the management, control and coordination of workers and subcontractors; site tidiness; the processing of variations.

Quality of service

As employers of the construction industry, clients expect a reasonable level of service from their providers, in this case contractors. In a study of client satisfaction factors, Ahmed & Kangari (1995) argued that in addition to major factors (i.e. cost, time and quality), other factors (i.e. client orientation, communication skills and response to complaints) play an important role. Here, quality of service is deemed to include response to complaints.

During interviews, clients and architects discussed the need for contractors to be responsive and to deal effectively with administration, to be committed to providing a satisfactory service to the client and to facilitate the design process. Commitment can further be explained as commitment of the key manager, i.e. director, contract manager and project manager.

Criteria at pre-construction stage

The evaluation of contractor performance commences at a very early stage in the contract. Such criteria may not be considered suitable for performance assessment, however their impact on the subsequent works may be of some magnitude. Aspects in this context include performance and presentation at first interview, ability and willingness to help develop the brief, contribution to design and buildability of the project, plan of work and method statement. In addition, a knowledge of contract requirements is important to ensure proper execution of the work.

Criteria at completion stage

To achieve a satisfactory level of performance, contractors need to remain focused and seek to ensure high levels of service to their clients throughout all stages of the project. Hence, this also includes satisfactory performance at project completion and hand-over. The interviews also revealed important performance criteria at this stage, including completion of defects, smoothness of hand over, ease / speed of settlement of final account, quality of hand over documents (operation and maintenance manuals, health and safety documents, etc.), and ease of delivery (general feeling on how things went).

5.3.1.2 Architect performance criteria

Tables 5.3 and 5.4 show the key architect performance criteria according to clients and contractors respectively. The emphasis here is on how clients and contractors consider architect performance. Similarly the criteria were categorised under several main headings and are now described.

Principal criteria

Well-established generic project performance criteria are founded on cost, time and quality (Ward *et al.*, 1991). It is argued that architect performance can also be gauged against such criteria. That is, architect performance impacts the achievement of satisfactory cost (*compliance to budget*), time (*timely delivery of information*) and quality (*general quality of building*) performance. These principal criteria are therefore deemed as important aspects of architect performance, as is *compliance to requirements* because it is essential that such requirements are met.

Table 5.3 Summary of clients' perceptions of key architect performance criteria

RANK	ARCHITECT PERFORMANCE CRITERIA	CLIENTS' RESPONSES												TOTAL
		1	2	3	4	5	6	7	8	9	10	11	12	
1	Timely information delivery	●	●	●					●		●	●	●	7
2	Design detail (quality of), clarity, completeness, reliability			●		●	●	●		●	●			6
3	Quality of design - relevant and practical (suitability of solution)		●		●		●				●			4
3	Quality of information - practicality / buildability			●					●			●	●	4
4	Technical skills / knowledge	●								●			●	3
4	Ability to manage/coor. the consultant team (mgt. skills)				●					●			●	3
4	Responsiveness to queries						●	●					●	3
5	Appropriate resources (suitability, quantity) res. management	●						●						2
5	Administration			●		●								2
5	Co-operation						●			●				2
5	Design presentation and visibility					●							●	2
6	Pro-active to problems encountered on site by regular visits	●						●						1
6	Practical construction knowledge	●												1
6	Communication skills	●												1
6	Listening to client wants		●											1
6	Understanding client culture		●											1
6	Design flair			●										1
6	Ability to administer the contract				●									1
6	Ability to maintain the quality aspect of the project (general quality)				●									1
6	Quality of design - provide value for money					●								1
6	Formulation of specification											●		1
6	Method statement (ability to explain)												●	1
6	Compliance to requirements										●			1
6	Ability to develop brief (resolution of the brief)												●	1
6	Adherence to fee agreement												●	1
6	Health and safety consideration												●	1
6	Environment consideration												●	1
6	Organisational skills and structure												●	1

Table 5.4 Summary of contractors' perceptions of key architect performance criteria

RANK	ARCHITECT PERFORMANCE CRITERIA	CONTRACTORS' RESPONSES									TOTAL
		1	2	3	4	5	6	7	8	9	
1	Timely information delivery	●	●	●	●	●	●	●	●		8
2	Quality of information			●	●		●	●	●	●	6
3	Co-operation		●	●	●	●	●				5
4	Design buildability	●				●		●			3
5	Accuracy of information in the forms of drawings and specs.	●	●								2
5	Willingness to produce detailed drawings	●		●							2
5	Responsiveness to queries				●					●	2
5	Design for value for money					●		●			2
5	Design considers environmental issues	●				●					2
5	Technical capability / practical construction knowledge	●					●				2
6	Response to feedback (e.g. revised drawings)	●									1
6	Avoidance of changes in design (e.g. due to client needs)	●									1
6	Attitude in dealing with client and contractor				●						1
6	Design adherence to budget								●		1
6	Commitment of resources (resource management) & key persons								●		1
6	Understanding of client culture									●	1
6	Design management and supervision					●					1
6	Understanding and compliance to regulations (CDM, fire)					●					1
6	Integrity						●				1
6	Keeping the client informed (willingness to involve client)			●							1
6	Compliance to requirements					●					1
6	Commercial attitude (i.e. avoidance of additional fees)					●					1
6	Communication skills					●					1
6	Ability to make decision promptly									●	1

The provision of timely information is considered most important by both clients and contractors. Seven out of twelve clients and nearly all contractors (8 out of 9) perceived this criterion to be significant. The failure to provide detailed design information has become somewhat of a stigma for architects in recent years. The provision of timely design information has been shown to impact the time performance of contractors (NEDO, 1988) and may explain why most contractors focused on this criterion in gauging architect performance.

Quality of design

Obviously, the architect's principal task is to produce a design that satisfies the needs of the client. Therefore, design quality is a fundamental part of architect performance. Sometime ago, the RIBA (1993) found that despite dissatisfaction with the quality of service (particularly in cost and project management), clients were highly satisfied with the quality of their designs. However, it is essential that this important aspect is monitored carefully. There are several aspects of design quality which are perceived to be important by clients and contractors, including the following:

- suitability of solution (relevancy, practicality),
- buildability,
- flair or aesthetic sense and innovation,
- value for money,
- health and safety,
- environmentally sympathetic.

Additionally, the quality of design information should also be assessed in terms of quality of detailed drawings and specifications (accuracy, completeness, etc.) because this helps to promote smooth project execution. This was expressed by half of the clients interviewed and ranked second.

Finally, in the longer term, any design should produce facilities that are simple to operate and easily maintained. Design should also take adaptability and sustainability concepts (i.e. in relation to life cycle cost) into account.

Management skills

Traditionally, as 'leader' of the project team, the architect was assigned the role of managing the construction contract. However, this role has shifted to other professions better able to manage projects (RIBA, 1992). From the contractor's perspective, Harding (1999) argued that very few architects have the construction management skills to justify their claim as team leaders. The impact of an architect's management skills on project performance is considerable. As an example, the inability to manage the design process effectively often causes late or inaccurate design information (Harding, 1999). Late information causes project delays, leading to client dissatisfaction. Therefore, architects should be aware of the need to improve their performance in this aspect.

Criteria for assessing architects' management skills include:

- quality / level of design management and supervision;
- ability to manage the construction process (here, as contract administrator);
- coordination between team members or consultants (as design leader);
- organisational skills and structure; and
- management of resources (including commitment of resources).

Technical skills

Architecture is considered as a unique blend of artistic and technical skills (RIBA, 1992). Technical skills are aspects of architect performance which are determinants of buildable and functional designs. Such criteria include:

- practical construction knowledge;
- suitability and quality of major building components or products selected;
- incorporation of mechanical and electrical services into the structure; and
- understanding and compliance to legislation and statutory requirements (CDM, fire, etc.).

These criteria were considered by Harding (1999) as typical shortcomings of architect performance.

Quality of service

As employers of the construction industry, clients expect a reasonable service from their providers, in this case architects. In a study of client satisfaction factors, Ahmed and Kangari (1995) argued that in addition to major factors (i.e. cost, time and quality), other factors (i.e. client orientation, communication skills and response to complaints) play an important role. Here, quality of service is deemed to include response to complaints.

The interviews with clients and contractors revealed that speed and reliability of service, responsiveness to queries, ability to make rapid and decisive decisions, commitment of key persons (active and continuous), willingness to produce detailed drawings (not only do conceptual work), and administration are required in order to provide a satisfactory service to the client and/or to facilitate the construction process.

Attitude of architect

As in the assessment of contractor performance, clients and contractors were found to apply similar intuitive criteria in assessing the performance of architects. Such criteria include spirit of co-operation / teamwork, proactive to problems encountered on site (e.g. by regular visits), communication with other coalition members, listening to client wants, avoidance of changes in design, attitude towards client and contractor, integrity, keeping the client informed (willingness to involve client), and commercial attitude (i.e. avoidance of additional fees).

Criteria at pre-construction stage

Evaluation of architect performance commences at a very early stage in the construction process. The impact of decisions made at these early stages (i.e. during the brief) has been well recognised. In these early stages, the performance of the architect is pivotal to successful project delivery, and therefore, any assessment must give due consideration to pre-construction criteria. Aspects at this stage include first interview and design presentation (visibility), ability to develop and resolve the brief, method statement (ability to explain how the project will be handled), and ability to understand the culture of the client and to assess their real needs.

5.3.1.3 Client performance criteria

Tables 5.5 and 5.6 show extracts of the key client performance criteria according to architects and contractors respectively. Again, these were categorised under several main headings and are now described.

Table 5.5 Summary of architects' perceptions of key client performance criteria

RANK	CLIENT PERFORMANCE CRITERIA	ARCHITECTS' RESPONSES																			TOTAL
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
1	Quality of brief (clarity, definite, specific)			●	●		●			●			●	●		●		●	●	●	10
2	Knowing what he wants	●				●			●	●		●			●	●			●		8
3	Ability to make rapid decision (rapidity, flexibility)	●						●	●	●				●		●					6
3	Understanding of the building process	●	●			●			●			●			●						6
3	Give achievable / realistic timescale			●	●	●						●		●				●			6
4	Sufficient / adequate budget		●		●						●	●					●				5
4	Timely payment (on schedule)					●	●	●			●						●				5
4	Adequate continuous involvement/commitment	●										●			●		●			●	5
5	Pay adequate fee (willingness to agree a fee, fair)					●				●							●			●	4
5	Trust, honesty and integrity						●				●						●		●		4
5	Attitude towards advice (respect, open to solutions, flexible)										●					●	●		●		4
5	Co-operativeness / team work	●				●		●									●				4
6	Responsiveness to quiries (quick feedback)						●												●	●	3
6	Not keep changing mind (clarity of thinking)							●			●								●		3
7	Be active in financial management (financial approval)	●						●													2
7	Understanding the difficulties and make allowances of it					●													●		2
7	Performance in pre-planning stage (early stage)										●				●						2
8	Help with monitoring	●																			1
8	Allow architect to enjoy project					●															1
8	Clarity of budget and programme						●														1
8	Ability to balance between involvement and interference									●											1
8	Well organised with the team									●											1
8	Administration									●											1
8	Appreciation of architecture														●						1
8	Ability to encourage attitude of proactiveness of all														●						1
8	Receptiveness towards ideas (design flair, opportunities)																●				1
8	Feeling on how enjoyable, pleasant client																●				1
8	Ability to convey/communicate inspiration																		●		1

Table 5.6 Summary of contractors' perceptions of key client performance criteria

RANK	CLIENT PERFORMANCE CRITERIA	CONTRACTORS' RESPONSES									TOTAL
		1	2	3	4	5	6	7	8	9	
1	Quality of brief (clarity, adequacy, appropriateness, etc.)	●	●					●	●	●	5
2	Timely payment		●		●	●				●	4
3	Know what he wants early			●	●				●		3
4	Co-operativeness		●				●				2
4	Trust, honesty and integrity		●				●				2
4	Ability in making decision					●			●		2
4	Adequate funding						●			●	2
4	Commitment/involvement to project			●			●				2
4	Provide adequate time								●	●	2
4	Support of information								●	●	2
5	Not change mind		●								1
5	Give lead designer/consultant proper level of authority		●								1
5	Responsiveness to problems that arise		●								1
5	Attitude to variations (caused by client changes)					●					1
5	Understanding of the building process							●			1
5	Help contractor work to deliver the product on time								●		1

Understanding of project requirements

Architects and contractors both consider this to be the most important aspect of client performance. It includes criteria related to the project brief, understanding of the building process, and ability to communicate requirements.

The client brief should be clear, adequate, appropriate, and specific in order to ensure successful project delivery and client satisfaction. However, evidence suggests that the inadequacy of the client brief still continues to cause problems during construction (e.g. Bresnen and Haslam, 1991; Barrett and Stanley, 1999). The poor performance of architects and contractors is often partly attributable to a poor client brief. In informal terms, clients should know what they want at an early stage without the propensity for changing their mind in the latter stages of a project. Furthermore, clients are expected to be able to communicate (i.e. convey) what they want to architects and contractors effectively.

Often, clients change their minds during both design and construction stages. This can cause problems to architects and contractors and may negatively impact both project and participant performance. Clients may claim that changes are inevitable and that architects and contractors should be capable of processing such, with little or no disruption. However, all participants can suffer because of the knock-on effect of such changes.

The client's understanding of the building process depends much on their experience. A conflict of opinion regarding this was revealed during the interviews. Several interviewees stated that it was the role of the 'construction professionals' (i.e. architects and contractors) to advise clients accordingly. However, some interviewees argued that it was the client's responsibility to possess a reasonable level of experience and sophistication.

The views of architects and contractors expressed in this research suggested a preference to work with experienced and knowledgeable clients. That is with clients who have at least some knowledge of construction.

Criteria related to finance

Fundamental to construction projects, clients (as project owners) must have adequate funds or be able to secure adequate funds. This was supported by Kometa *et al.* (1995) who found that according to the views of project consultants, project finance was the most important responsibility of clients. Several aspects related to finance were identified during the interviews, including adequacy of funding, timeliness of payment and ease of financial approval (e.g. associated with variations). Moreover, a number of architects suggested that a willingness to agree a fee in advance was crucial to the survival of their companies.

Criteria related to decision making

Cherns and Bryant (1984) found that client organisations are complex and not unitary. This often causes problems in the decision making process within client organisations. However, the decisions that clients must make, are often in the crucial period of project execution and may significantly affect architect and contractor performance. Therefore, clients are expected to be able to make decisions effectively and consistently, without undue delay.

Criteria related to management skills

Traditionally, architects are often appointed as lead designers and are expected to communicate the client's requirements to the contractor (e.g. through working drawings and informed meetings). Lead designers are expected to make important decisions on behalf of their clients in order to keep within budget and to schedule. If this authority is not properly delegated and communicated, delays can result and less than optimal project performance results. Clients should delegate and define to their designers their authority at the outset.

One architect felt that clients should organise their project team (i.e. client representatives) in order to ensure that the project is well administered. Moreover, pre-planning by clients was also considered extremely important if their architects and contractors are expected to perform effectively.

Support criteria

Both architects and contractors indicated the need for support and involvement from their clients. Foremost, is information support, particularly in terms of quality and timeliness. It was felt that clients should also set adequate / realistic time frames for the design and construction phases. One architect suggested that the client's role in monitoring contractor performance was also contributory to successful project implementation. A caveat to this was the need to strike a balance between an adequate level of involvement and what could be construed as interference. It has become widely accepted that successful project performance requires client involvement, however, if clients become too involved, then this soon becomes interference which hampers the performance of their professionals and contractors alike (CIRIA, 1987).

Attitude of client

Nearly all architects and contractors suggested that the 'attitude' of the client has a significant influence on the satisfaction / dissatisfaction of the PC. Such criteria identified from interviews include: integrity and honesty, team work/ spirit of co-operation, responsiveness to problems, understanding architect / contractor difficulties, attitude to variations caused by client changes, allowing architect / contractor to 'enjoy' projects, appreciation of architecture, ability to encourage pro-activeness among parties, attitude towards advice, and client personality (e.g. general feeling on the pleasantness of the client).

5.3.1.4 Discussion of performance criteria

Although the nature of the criteria mainly focuses on the roles and responsibilities of each participant in the PC, some common characteristics identified are as follows:

- Most criteria are considered to be rather subjective and somewhat softer in nature (in contrast to hard measures such as time and cost). Hence, it would appear that these 'people issues' such as spirit of co-operation, honesty, pro-active towards problems, etc. are pivotal to project success. These characteristics represent the foundations on which harmonious relationships among participants in the PC can be built. This concurs with Swan and Combs (1976) who argued that performance (particularly, of a product) is fundamentally assessed based on expressive (i.e. non-material, psychological, 'soft') and instrumental (i.e. physical, 'hard') dimensions. Furthermore, Zeithaml *et al.* (1990) cited in Gable (1996) suggested that customers do not evaluate service quality based on the outcome of a service alone, but they also consider the process of service delivery. That is, in the construction PC, an assessor (e.g. client) evaluates both the outcome of a service, e.g. constructed building, and how a performer (e.g. contractor) delivers that building.
- Some criteria highlight the performance interdependency that exists amongst the participants, as described in the review of literature (refer to Chapter 2). These include,

for example, information support, particularly in terms of quality and timeliness, adequate / realistic time frames for design and construction, listening to and understanding the problems of others, and willingness to produce detailed drawings (not only do conceptual work).

The preceding sections have revealed the multivariant performance criteria as expressed by practitioners. This suggests that to measure performance, multiple aspects of performance must be considered. These performance aspects interdependently influence satisfaction / dissatisfaction feelings throughout the project. That is, high levels of satisfaction (i.e. excellent performance) in one aspect will be diminished by dissatisfaction (i.e. poor performance) in other aspects (Swan and Combs, *ibid.*). Hence, the need to adopt multivariant performance criteria can be summarised as follows:

- The performance of an individual is not measured by a single aspect alone. In addition to the main aspects of performance (e.g. need for an architect to produce a good design), there are many other aspects which can cause dissatisfaction to other participants. To obtain a comprehensive view of participant performance, all relevant aspects should be included and measured separately in order to achieve a complete understanding .
- Since measures of performance, and hence satisfaction, are psychological in nature, consideration needs to be given to more than just one aspect of the psychological process (Smith *et al.* 1969). Hence, multiple measures should be utilised simultaneously to reflect each aspect of performance.
- As previously described, satisfaction is an abstract concept. Smith *et al.* (*ibid.*) commented:

> "An abstract concept can be a single element of a theory. On the other hand, the concept may not be adequately represented by a single operational measure because of both the complexity of the concept and the limitations of specific measures. As a strategy it may be most productive in such circumstances to use multiple measures in an attempt to obtain data converging on the abstract concept."

These reasons justified the inclusion of multivariant performance criteria for each participant in the questionnaires. However, it was important to note that the appropriateness of data representing these multivariant criteria had to be considered based on subsequent analyses (refer to section 8.4) prior to their utilisation in the model development.

5.3.2 Performance Attributes

Tables 5.7 to 5.11 inclusive present summaries of the key participant performance attributes according to the views of the practitioners. In this research, performance attributes are defined as characteristics representing the nature of a particular participant which affect that participant's performance. The first column of the tables displays the participant attributes and the following columns represent the responses of the participants during interviews. As before, each participant (e.g. contractor) was invited to discuss the performance attributes of the other two participants (e.g. architect and client).

Architects and contractors found it difficult to advise on client performance attributes. That is, architects and contractors are seldom in a position to choose their clients or comment on client performance. Therefore, some interviewees were unable to answer questions in this regard, hence omission of some architects and contractors in Tables 5.9

Table 5.7 Summary of architects' perceptions of key contractor attributes

CONTRACTOR ATTRIBUTES	ARCHITECTS' RESPONSES													
	1	3	5	6	7	8	9	10	11	14	16	17	18	19
Capacity														
Size of firm		●	●									●	●	
Firm turnover								●	●				●	
Current work load	●				●									
Financial issues														
Financial soundness / stability	●				●	●	●		●		●	●		●
Price (selection criteria)										●				
Experience														
General experience			●	●			●	●					●	
Relevant past experience (type, size and location of project)		●	●		●	●		●	●		●	●	●	
Past performance and reputation														
General past performance				●	●	●	●		●	●		●	●	●
General reputation			●			●	●							
Reputation in on budget completion											●			
Reputation in on time completion		●						●			●			
Reputation in claims		●		●										●
Reputation in litigation		●												
Personnel														
Site personnel (qualification and experience of), CV	●	●	●		●			●	●		●		●	
Selection of site personnel (influence)											●			
References				●	●						●	●		
Location (remoteness of site from head office)			●											
Health and safety records	●				●			●			●			
Quality assurance / control					●									
Previous working relationship		●		●									●	●
Adequacy of resources							●					●		
Company structure / site organisation	●				●						●			

Table 5.8 Summary of clients' perceptions of key contractor attributes

CONTRACTOR ATTRIBUTES	CLIENTS' RESPONSES											
	1	2	3	4	5	6	7	8	9	10	11	12
Size of firm, catchment (matched with size of project)		•		•	•		•	•	•			•
Financial issues												
Financial soundness / stability				•		•	•		•		•	•
Price (selection criteria)		•			•		•	•				
Experience												
General experience							•			•		•
Relevant past experience (type, size and location of project)		•	•			•			•	•		
Past performance and reputation												
General past performance	•	•							•			
General reputation	•			•			•				•	•
Past performance in quality products				•				•				
Past performance in the last project									•			
Reputation in on time completion	•							•				
Customer care type of contractor (reputation)				•								
Reputation in litigation				•								
Site personnel (qualification and experience of), CV		•			•	•	•					•
References						•	•		•		•	
Location (remoteness of site from head office)							•	•				
Health and safety records	•							•				
Previous working relationship			•									
Training provisions					•							
Operational structure / site organisation		•			•	•	•					

Table 5.9 Summary of architects' perceptions of key client attributes

CLIENT ATTRIBUTES	ARCHITECTS' RESPONSES													
	2	3	4	6	7	8	9	10	12	13	14	15	16	19
Size of organisation							•							
Type of client (to match with architects' skills)				•							•			
Financial soundness					•				•			•		•
Past performance and reputation														
Past performance / track records						•			•					
General reputation (personality, who client is)						•		•						
Reputation in paying on time		•						•						
Construction department														
Technical department (quality of)	•													
Level of experience (knowledge and management)	•	•								•	•	•		
Project characteristics														
Client's size of project		•												
Client's area of design demand (e.g. building type)		•						•						•
Interesting jobs (quality of architecture)			•					•						
Previous working relationship (director levels)		•		•			•							
Recommendation of others						•								
Quality of client's organisation							•			•	•			
Potential for repeat work							•						•	

Table 5.10 Summary of contractors' perceptions of key client attributes

CLIENT ATTRIBUTES	CONTRACTORS' RESPONSES			
	2	4	6	9
Financial soundness	•		•	•
Past performance and reputation				
Past performance / track records	•	•		•
General reputation			•	
Previous working relationship	•		•	
Employ their own professional team	•			
Potential for repeat work			•	

Table 5.11 Summary of clients' perceptions of key architect attributes

ARCHITECT ATTRIBUTES	CLIENTS' RESPONSES								
	2	3	4	5	6	7	8	9	12
Capacity									
Size of firm	●					●			
Turnover						●			
Financial issues									
Financial stability / soundness					●	●			●
Selection criteria: fee	●							●	
Relevant experience (type & size of project)	●	●		●	●	●	●	●	●
Past performance and reputation									
Past performance (track records)	●			●	●		●	●	●
Reputation									●
Reputation in additional fees									●
Personnel									
Number of personnel employed					●	●			●
Quality of personnel (e.g. CV), liaison	●				●	●			●
Number of qualified architect, e.g. RIBA						●			
References					●	●		●	
Region (i.e. catchment area, geographic)	●				●				
Quality assurance system									●
Previous working relationship (director levels)		●	●			●			
Quality of sub-consultants work for architect									●

and 5.10. In a similar vein, the majority of contractors interviewed could not identify architect performance attributes mainly because they had not been involved in architect selection. Therefore, these were identified based on clients' perceptions alone (refer to Table 5.11). In contrast, the clients and architects interviewed were confident in their appraisal of contractor attributes, since these were often applied during contractor selection procedures.

Notwithstanding the problems encountered, the interviews revealed numerous performance attributes. Generally, the findings were consistent with those identified in the literature. A degree of commonality amongst the different participants was apparent in that certain attributes were identified on more than one occasion. There were, however, several attributes, which had not previously been identified in the literature, that were considered relevant for this research, and for inclusion in the major survey. They are now described:

Performance in the last project

The perceived performance of a company is always changing due to the uncertainties involved in the construction process. One client stated that the performance of a contractor is only as good as the last project undertaken. This suggests that the reputation of a company is only as good as the level of performance achieved on the most recent project. This attribute is considered equally applicable to all service providers including architects.

Quality assurance system (for architect)

One client felt that a quality assurance system represents a useful attribute of architect performance. The literature review conducted found this attribute to be relevant for the contractor only (see section 3.2.4.3).

Reputation for additional fees (for architect)

This is a performance attribute for architects, and is similar to the contractor attribute of being claim conscious (see section 3.2.4.3). Clients interviewed suggested that architects who claim for additional fees, cause to damage their reputation.

Appointment of site personnel

The interviews revealed the perceived significance of site personnel to project performance. Some clients preferred to have the opportunity to choose the site and/or key personnel of their contractors and architects. Here, personnel would be chosen on the basis of those more likely to bring about satisfactory project performance.

Availability and capability of client's construction department

Clients, who regularly procure construction works, normally have a dedicated department who specifically deal with construction. These departments normally consist of employees educated and experienced in construction. These clients are considered sophisticated / experienced clients and more likely to be able to perform to the standard required.

5.4 SUMMARY

In this research, interviews were used to identify performance criteria of each participant, and to support and confirm the findings of the literature review in respect of performance attributes. Based on forty interviews with a number of clients, architects and contractors, performance criteria for each participant were compiled. Additionally, performance attributes for each participant helped to confirm the findings of the literature review. Several additional attributes identified were considered relevant for the research. The findings of the interviews and the literature review provided a basis on which the questionnaire could be developed for the major survey. The next chapter explains in detail the nature of this main data collection process and preliminary data analysis.

Chapter 6

Data Collection and Preliminary Data Analysis

6.1 INTRODUCTION

This chapter describes the methodology employed for data collection and preliminary data analysis. Firstly, the decision to implement a questionnaire survey is explained and justified followed by explanation of the research design. Then, development of the questionnaires is described, including question design, scale of measurement and format. The distribution of the questionnaires is explained, followed by the results of the survey. Finally, procedures for preliminary data analysis are explained in detail.

6.2 MAIN DATA ACQUISITION

Yin (1994) categorised five major strategies in the social sciences, i.e. experiments, surveys, archival analysis, histories, and case studies. The selection of an appropriate research strategy for a particular research is dependent on three conditions consisting of (i) type of research question, (ii) the extent of control an investigator has over actual behavioural events, and (iii) the degree of focus on contemporary as opposed to historical events (Yin, *ibid.*). In this research, the most relevant selection driver was the type of research question. Given the 'what' research question and given that various strategies are not mutually exclusive (Yin, *ibid.*), the possible strategies were survey and case study. Each strategy has it own advantages and disadvantages. Case studies provide in-depth exploration but can also be criticised as suffering from a lack of rigour (i.e. possibility of bias on behalf of researcher), a lack of representativeness and to be very time consuming

(Yin, *ibid.*). Considering the research objectives and time frame, a survey approach was finally chosen as the strategy to elicit the required data.

Within the survey strategies, data can be collected directly using questionnaires, interviews, or direct observation, or indirectly, from written or electronic records and documents (Bourque and Clark, 1994). Since this research focuses on attitudes and satisfaction / dissatisfaction feelings of people, data had to be collected directly using either questionnaires or interviews. Subsequent consideration of the advantages and disadvantages of both methods, and based on the experience of interviews conducted earlier in the research (refer Chapter 5), led to the decision to choose questionnaires as the major survey / data collection instrument. This method was considered more cost-effective and less time-consuming than interviews, and would provide the required volume of data for analysis purposes.

6.2.1 Research Design

The main participants of the project coalition (i.e. clients, architects and contractors) were targeted as part of the major survey. Each respondent (e.g. client) was asked to assess the performance of the other two participants (e.g. architect and contractor) on a particular case project (explained in section 6.2.2.3). Table 6.1 provides a summary of this design. In the example used above, client respondents were required to assess the performance of the architect and contractor on their selected case project. This approach provided six performance assessment cases in total (i.e. two for each type of participant).

Three different questionnaires were designed based on those attributes and criteria compiled in chapters 3, 4 and 5, and used in the survey.

Table 6.1 Research design

Respondent	Performance Assessment		
	Client	Architect	Contractor
Client	-	✓	✓
Architect	✓	-	✓
Contractor	✓	✓	-

6.2.2 Overview of the Questionnaires

To set the tone for the investigation, a covering letter was first developed (refer to Appendix A2). This was to introduce the respondents to the research programme and objectives, and to provide an overview of the potential benefits for each participant.

Respondents were asked to identify a particular UK building project (procured using the traditional route or a form of partnering) in which they were recently (i.e. within 2 years) involved (referred to as the 'case project'). The respondents were asked to relate all their answers to the questions contained in the questionnaire to this 'case project'. This enabled the research to capture the real attributes influencing a respondent's satisfaction / dissatisfaction feelings. To protect the confidentiality of the other parties involved in this case project, respondents were not asked to identify projects, nor to name other participants, etc.

The structure of the questionnaire was in four sections. The first section sought information concerning respondents and their employers. The second section sought to categorise the characteristics of the case project. The third and fourth sections required the respondents to indicate the attributes and levels of satisfaction of key participant performance criteria.

Respondents were given assurances that the information provided would be held in strict confidence and used for research purposes only. Respondents were also asked to indicate whether they would like to receive a summary of the research findings and were provided with a self-addressed envelope for the return of the questionnaire. An example of how the questions were to be answered was also provided. Finally, they were invited to contact the researcher in order to discuss any queries.

6.2.2.1 Question design

In questionnaire design, there are two principal types of questions, i.e. open-ended and closed-ended questions. The type of questions used should consider how the data will be analysed. Furthermore, the type of questions should also encourage responses. Open-ended questions are easier to write but they are generally more difficult to answer, code and analyse. Although closed-ended questions are much more difficult to design, they allow more efficient data collection, processing and analysis, if designed and tested carefully (Bourque and Clark, *ibid.*). Considering these advantages and disadvantages, closed-ended questions were chosen. In designing the questionnaire, every effort was made to ensure that respondents could conveniently answer each question. Lay-out, wording and sequencing were given due consideration in this respect. All questions required the respondent to merely circle or provide a numerical answer.

6.2.2.2 The scale of measurement

Basically, there are four levels of data in statistical analysis. They are nominal, ordinal, interval and ratio with increasing levels of measurement. Scale is important because it limits the statistics that can be appropriately used (Weisberg, 1993). For the purpose of analysis, it is best to collect interval level data since statistics such as mean, standard deviation and correlation can be interpreted (Bourque and Clark, *ibid.*). However, in this research, there are certain attributes which could not be collected in this way, such as type of procurement, type of contract, etc. Hence, for these, data was collected in a nominal form. Data such as number of company employees (especially when respondents were asked other company's number of employees) were best collected in the form of ranges, i.e. ordinal data, because this form allows easier recall (Fellows and Liu, 1997). Moreover, such data may be subject to constant change (e.g. number of company employees) and therefore, approximate values in the form of ranges are better and easier to collect.

Subjective measures (e.g. company attributes and performance assessment) were presented using a continuum, and data was collected using various forms of Likert scales ranging between 0-10, and thereby providing continuous (i.e. interval) data. This method is widely used in the social sciences, as well as in construction management. An eleven point scale was selected since this provides opportunity and flexibility for subsequent (e.g. sensitivity) analysis. In construction, to name a few, Anderson and Tucker (1990) utilised this method in their research to assess the current utilisation of recommendations and performance for construction industry improvement. Diekmann *et al.* (1994) used a similar method to measure attributes influencing propensity of construction disputes. Additionally, Cheung *et al.* (2000) used this method to measure variables affecting project dispute resolution satisfaction in Hong Kong. However, Oppenheim (1992) advocated two conditions which are essential in using a rating system. Firstly, dimension of the scale must be defined. Here, the scale was appropriately defined at its lowest and highest levels. Secondly, error of central tendency must be considered. This stems from the fact that respondents tend to answer in the middle of a scale (undecided) if the scale lacks true definition (Diekmann *et al.*, *ibid.*). To address this issue, the terms used in the questionnaire were limited to those considered common knowledge for construction practitioners (i.e. the respondents) and the questionnaires were designed and tested carefully (see section 6.2.3.1).

6.2.2.3 The questionnaires

The questionnaires for each of the three participants are presented in Appendix B. As previously described, the questionnaires were structured in four main sections.

The first section included respondent details, respondent (i.e. assessor) attributes and company (i.e. employer) attributes. Respondent details sought information regarding name of respondent, name of employer, contact address, telephone, facsimile and e-mail address. This was required in case there was a need to contact respondents for clarification purposes, for sending a summary of the research findings (if asked) and/or for filing purposes. Respondent attributes represent the attributes of an assessor (e.g. vocational background) which may influence their own assessment of performance (refer to section 4.4.3). Company / employer attributes represent those attributes of the company (e.g. annual turnover) which may influence performance assessment (refer to section 4.4.4).

The second section sought information regarding the 'case project' (e.g. procurement route). This included controllable and uncontrollable project attributes as identified in section 3.3.

The third and fourth sections sought information regarding the performance of the other two participants. This included performance attributes (refer to section 3.2) and performance criteria (refer to section 5.3.1) of these other two participants. The respondents were asked to indicate their level(s) of satisfaction for each criterion on a scale of 0 to 10 (representing a continuum between extremely poor and excellent respectively) based on the aforementioned 'case project'. Thus, the level of satisfaction illustrates how well the participant (i.e. performer) is performing a certain task according to the opinion of the assessor.

6.2.3 Distribution of the Questionnaire

Following development of the three questionnaires and before undertaking the major survey, a pilot survey was undertaken to help improve their final format. The following sections describe the distribution of the questionnaires, starting with the pilot survey and then the strategy used in the distribution of the major survey.

6.2.3.1 Pilot survey

A pilot survey is considered one of the most important steps in designing and planning a research survey (Neuman, 1997). This process is important because the wording and sequence of questions can facilitate recall and motivate more accurate responses (Aaker *et al.*, 1998). Neuman (*ibid.*) also stated that if respondents have diverse backgrounds and frames of reference, exactly the same wording may not have the same meaning.

The primary purpose of the pilot survey was to generate feedback from practitioners regarding the design and format of the questionnaires, and to make amendments as necessary prior to undertaking the major survey. The coalition participants previously interviewed were targeted as respondents for the pilot survey. Results from the pilot survey are presented in section 6.3.1. In addition to completing the questionnaire, respondents were invited to comment on the lay-out, clarity and comprehensiveness of the questionnaires. The pilot survey resulted in minor amendments being made to the questionnaires, and also helped to reduce the extent of the documents.

6.2.3.2 Major survey

Following the development of the questionnaires and implementation of a pilot survey, a UK-wide questionnaire survey of clients, contractors and architects was conducted. A major disadvantage of mailed questionnaires is the low response rate often received (Bourque and Clark, 1994). In order to maximise the response, the questionnaires were sent to named individuals within companies identified by the author (see later). Bourque and Clark (*ibid.*) reported that while this strategy increases the likelihood of a response, there is no guarantee that the questionnaire will be completed by the designated person.

Due to the comprehensive nature of the questionnaire, a two-stage distribution strategy was used with the intention of generating more responses. Data collected from the first stage of this strategy were subjected to preliminary analysis using bi-variate correlation analysis between attributes (as independent variables) and performance criteria (as dependent variables) to identify likely significant attributes influencing expressed satisfaction / dissatisfaction. This analysis is explained in detail in section 6.4.2. The questionnaire was then amended incorporating only those attributes found to be significant, hence reducing the length of the questionnaire for the second stage of the major survey.

Experienced U.K. private and public clients, defined as those who regularly procure construction works from the industry, were targeted in the survey of clients. Private clients consisted of developers, retailers and financial institutions. Retailers and financial institutions were identified from the listing of Key British Enterprises (Dun and Bradstreet, 1998) representing the top U.K. retailers and financial institutions. Details of the names of individuals who deal with construction projects on behalf of such organisations, were identified via initial telephone enquiries. Developers were identified from the Estates Gazette (1999), whose directors or managing directors were identified from the Kompass Directory (1999-2000). Public clients, i.e. local authorities or City Councils, were identified from the Municipal Year Book (Lauren Hill (*ed.*), 1999). The questionnaires were addressed to the Head of Property Services, within each of the local authorities / City Councils.

Contractors were identified from the listing of Key British Enterprises (Dun and Bradstreet, 1998) representing the top U.K. contractors and the Kompass Directory (*ibid.*), which included the names of all such directors or managing directors. Additionally, chartered building companies (CIOB, 1998/1999) were also targeted in the second stage of the survey.

Architects were identified from the list of top U.K. architects (Knutt and Osborne, 1998) and the RIBA Directory (RIBA, 1998). The RIBA Directory provides the names of the principal architects and/or directors.

6.3 SURVEY RESULTS

The following section presents the results of the pilot and major surveys. Amendments to the questionnaires based on the response to the pilot survey are described. A summary of the response to all the surveys is also presented.

6.3.1 Pilot Survey and Questionnaire Amendments

The response to the pilot survey is presented in Table 6.2. Six clients, 4 architects (including one unusable) and 6 contractors (out of the 12, 18 and 9 respectively who had previously been interviewed) responded. The results were not only used to amend the final format of the questionnaires, but were also combined with the response to the major surveys and used in the subsequent data analysis.

Table 6.2 Summary of questionnaire distribution and responses

Questionnaire	Stage	Sent	Response	Percentage of response
Client	Pilot	12	6	50.0
	1st stage	254	33	13.0
	Sub-total	*266*	*39*	*14.7*
	2nd stage	270	38	14.1
	Total	***536***	***77***	***14.4***
Architect	Pilot	18	4	22.2
	1st stage	250	29	11.6
	Sub-total	*268*	*33*	*12.3*
	2nd stage	260	37	14.2
	Total	***528***	***70***	***13.3***
Contractor	Pilot	9	6	66.7
	1st stage	200	27	13.5
	Sub-total	*209*	*33*	*15.8*
	2nd stage	302	48	15.9
	Total	***511***	***81***	***15.9***
	Grand total	**1575**	**228**	**14.5**

In response to the comments of the pilot survey participants, a number of minor revisions were made to the questionnaires, mainly in connection with the variables listed under certain questions. Certain variables were considered beyond the knowledge of participants and were subsequently removed. Additionally, several wording amendments were made in accordance with the respondents' comments. A summary of these is presented in Table 6.3. Having completed the amendments, the questionnaires were considered ready for use in the major surveys.

Table 6.3 Wording amendments made based on the results of the pilot survey

Attributes (variables)	Pilot questionnaires	Final questionnaires
Respondent (perception of clients)	Less involved (hidden behind the screen)	Remote from construction process
	Tend to be influenced by their advisors	Tend to be influenced by their initial advisors (e.g. QS, architect)
Respondent (perception of contractors)	Claims conscious	Too willing to 'build claims'
Project (cause of variations)	Client (choice, forced)	Client
	Architect (choice, defects, brief)	Architect
	Contractor (document, information, management)	Contractor
Architect	References from other contractors and clients	References from other clients

6.3.2 Major Survey

As previously described, the questionnaire survey was administered in two stages. In the first stage, 254 client, 250 architect and 200 contractor questionnaires were distributed (i.e. 704 in total). After preliminary data analysis (see section 6.4), each of the three questionnaires was revised (i.e. reduced). Then, a further 270 client, 260 architect and 302 contractor questionnaires were distributed in the second stage. Table 6.2 shows the results of the surveys. The response rates of the second stage were slightly better than those of the first stage. In total, 1575 questionnaires were distributed from which 228 completed questionnaires were received representing a 14.5 percent response rate. This relatively low response rate is about the 'norm' for construction management research and in many ways can be associated with the 'confidential' nature of the questions and the comprehensive nature of the research instrument.

While sections three and four of each questionnaire sought information regarding the performance of the other two participants, some respondents were only able to complete one section due to a lack of information or because of the procurement route used on the selected case project. Table 6.4 shows the excluded and useable responses to the pilot and major surveys.

Table 6.4 Summary of excluded and useable responses

Respondent	Assessment of	Excluded responses			Useful responses		
		Pilot and 1st stage	2nd stage	Total	Pilot and 1st stage	2nd stage	Total
Client	Architect	7	1	8	32	37	69
	Contractor	0	0	0	39	38	77
Architect	Client	1	0	1	32	37	69
	Contractor	4	1	5	29	36	65
Contractor	Client	1	0	1	32	48	80
	Architect	7	1	8	26	47	73

6.4 PRELIMINARY DATA ANALYSIS

The preliminary data analysis aimed mainly at reducing the number of variables in order that the second stage questionnaires could be reduced with a view to attracting the additional responses required for modelling. Data obtained from the second stage of the survey was combined with that acquired from the first stage and used for developing and validating the models. The analysis for each participant (i.e. clients, contractors and architects) followed two steps. First, data were screened for quality (i.e. to ensure that the data used contained as few missing values as possible). Secondly, correlation analysis was applied to select potentially important independent variables. For the purposes of clarity, a detailed explanation of this two-step process is provided for just one of the performance assessment cases, i.e. based on the architects' assessment of contractor performance. This process was repeated for each participant's performance assessment.

6.4.1 Data Screening

Data screening was undertaken to obtain a database appropriate for analysis. Cox and Snell (1981) recommended checking data quality before further analysis. One method involves checking for missing observations. The performance criteria data (i.e. dependent variables) and performance and satisfaction attributes (i.e. independent variables) were manually inspected. If there were 10 or more missing values in any particular case project (i.e. completed questionnaire), the case was excluded from the analysis. This led to the exclusion of several responses as shown in Table 6.4. Any variable with more than 20% missing values was also excluded from analysis. Table 6.5 provides a summary of the number of variables excluded for each assessment. These variables were considered beyond the knowledge of respondents since a significant percentage of respondents refused and/or failed to give information. These thresholds for missing values were arbitrarily chosen as advocated in research by Torbica (1997).

Table 6.5 Summary of number of original and excluded independent variables in each performance assessment

Respondent	Assessment of	Original	Deleted (20% missing)	Excluded by corr.	Remaining	For Analysis
Client	Architect	80	8	37	35	41
	Contractor	87	10	41	36	47
Architect	Client	72	3	43	26	42
	Contractor	80	6	38	36	47
Contractor	Client	73	2	38	33	42
	Architect	73	8	34	31	41

Note: This table was extracted from Tables E1-E3 in Appendix E.

6.4.2 Selecting Potentially Statistically Significant Variables

The purposes of this analysis were two fold: first, to obtain a more manageable (i.e. smaller) number of variables which had the potential to be important variables and so allow efficient and effective analysis to be conducted; and second, to reduce the length of the questionnaires to be used in the second stage survey in order to obtain the response required to allow meaningful statistical analysis.

The basis of the intended modelling technique (multiple regression) is correlation analysis. To obtain an optimum model, independent variables should not highly correlate with each other but should highly correlate with the dependent variable. Therefore, potentially useful predictors (i.e. statistically significant independent variables) were selected based on their correlation with the dependent variables (i.e. satisfaction measures) as shown in Tables D1-D3 in Appendix D. The satisfaction measures were derived from applying the principal components analysis technique to the performance criteria, and their validity and reliability were confirmed (similar process as section 8.4.3 and 8.4.4). This was conducted to reveal multiple measures of satisfaction and the need to rigorously identify significant independent variables. This preliminary analysis used data collected from the pilot survey and that from the first stage of the main survey (refer to Table 6.2). Results of this process are summarised in Tables E1-E3 in Appendix E. This correlation method was used by Edwards (1999) as a preliminary analysis tool to determine significant variables in a study of maintenance costs.

Performance and satisfaction attributes (i.e. independent variables) were correlated with satisfaction measures (i.e. dependent variables) in each performance assessment case (e.g. contractor performance assessed by clients). Correlation matrices were derived and analysed for all cases (six cases in this research). Any independent variables, which had a significant correlation (i.e. equal to or better than the 5% confidence level), were selected for inclusion in the revised questionnaires and used in the second stage survey. Table 6.5 presents the original and reduced numbers of independent variables. Variables retained for each participant were kept the same for both assessors (refer to Table 6.5, 7th column). For example, in the assessment of client performance, 42 independent variables were used by both architects and contractors. However, for each assessment, the initial number of significant variables was different (refer to Table 6.5, 6th column). Correlation analysis identified 33 significant variables based on the contractors' assessment, however, only 26 significant variables were identified in the architects' assessment (refer to Table 6.5, 6th column, row 3 and 5). While some variables were significant in both assessments (i.e. by contractors and architects), some were only significant in one assessment. All significant variables identified by either contractors or architects were included for further data collection and analysis to ensure comprehensiveness and comparability of the findings.

6.5 SUMMARY

This chapter has described the data collection process and preliminary data analysis procedures. The design of the research and development of the questionnaires has been described including question design, the scale of measurement and general format. The questionnaires were subsequently piloted with the co-operation of the interview participants. Based on the response to the pilot survey, several variables were excluded and minor wording amendments made to the final format of the questionnaires. A two-stage major survey strategy was implemented. After the first stage, the data were analysed resulting in the development of shortened versions of the questionnaires which were then used in the second stage survey. Data obtained from the questionnaire surveys (both pilot and major surveys) were used as the basis for analysis and model development. The next chapter will present and discuss the characteristics of the case projects based on descriptive and bi-variate analyses.

Chapter 7

Characteristics of the Case Projects

7.1 INTRODUCTION

With the aim being to acquire information that could be useful for subsequent interpretation of the models developed, this chapter presents a discussion of the characteristics of the case projects identified in the survey. First, descriptive analysis of the significant independent variables representing the characteristics of the case projects is presented and elaborated. Then, further analysis concerning the relationships between these variables is presented and discussed.

7.2 GENERAL DESCRIPTIVE ANALYSIS

Table 7.1 depicts the types of case projects categorised as new build, refurbishment and extension to existing premises, based on the responses of clients, architects and contractors. The majority of case projects involved in this research were new build projects (60.9%). This was followed by refurbishment projects and extension to existing premises, which accounted for 26.2% and 12.9% respectively. Distribution across the different respondents (i.e. clients, architects and contractors) shows a similar tendency.

Table 7.2 shows the classification of the case projects based on type of building. Case projects were categorised into public (e.g. schools, leisure facilities), office, retail, residential and industrial buildings. Overall, public buildings were dominant, followed by office, residential, industrial and retail buildings respectively. Distribution across the different respondents suggests a similar tendency.

Table 7.1 Types of project

Respondent	New build	Refurbishment	Extension to existing premises	No. case projects
Client	48 62.3%	22 28.6%	7 9.1%	77 100.0%
Architect	44 63.8%	17 24.6%	8 11.6%	69 100.0%
Contractor	45 57.0%	20 25.3%	14 17.7%	79 100.0%
Overall	**137** **60.9%**	**59** **26.2%**	**29** **12.9%**	**225** **100.0%**

Table 7.2 Types of building

Respondent	Public	Office	Retail	Residential	Industrial	No. case projects
Client	33 42.9%	18 23.4%	13 16.9%	13 16.9%	8 10.4%	77 100.0%
Architect	22 31.9%	22 31.9%	6 8.7%	13 18.8%	6 8.7%	69 100.0%
Contractor	24 30.8%	18 23.1%	5 6.4%	17 21.8%	14 17.9%	78 100.0%
Overall	**79** **35.3%**	**58** **25.9%**	**24** **10.7%**	**35** **15.6%**	**28** **12.5%**	**224** **100.0%**

Table 7.3 presents the procurement routes employed on the case projects. Generally, sixty one percent of case projects employed the traditional route indicating the on-going popularity of this kind of procurement route. Partnering was used in 20 percent of the case projects. This is significant and indicates that the industry may be moving towards 'relationship-based' procurement routes. The use of partnering needs to be encouraged as it can bring a positive influence on performance (Egan, 1998). Design and build was used

in 17 percent of the case projects. Very few case projects used construction management systems. Distribution across different respondents suggests a similar tendency, except for contractor respondents where design and build was second after the traditional route.

Table 7.3 Procurement routes employed in the case projects

Respondent	Traditional	Design and build	Partnering	Construction Management	No. case projects
Client	48 62.3%	11 14.3%	17 22.1%	1 1.3%	77 100.0%
Architect	41 59.4%	10 14.5%	15 21.7%	3 4.3%	69 100.0%
Contractor	48 60.0%	18 22.5%	13 16.3%	1 1.3%	78 100.0%
Overall	**137** **60.6%**	**39** **17.3%**	**45** **19.9%**	**5** **2.2%**	**226** **100.0%**

Table 7.4 presents the planned duration and duration overrun on the case projects. Average planned duration was 11 months and 4 days (11.13 months). Minimum planned duration was one and a half months and maximum duration was three years and 10 months. Overall median and mode were nine and six months respectively. Evaluation of the frequency table (refer to Table 7.5) revealed that seventy percent of the case projects were less than one year in duration and ninety percent were less than eighteen months in duration. It is worth noting that 57 percent of the case projects were completed behind schedule. Similar percentages were found for each type of respondent. These findings indicate that delays are not uncommon. The range of overrun was between one week and nine months and one week. Average overrun was 2 months and 3 days (2.11 months).

Table 7.4 Project duration (in months)

Respondent	Planned project duration			% of projects Which overrun	Overrun duration		
	Min	Average	Max		Min	Average	Max
Client	1.5	10.24	25	56.6%	0.25	2.07	6
Architect	2	13.33	36	61.8%	0.35	2.25	9.25
Contractor	3	10.11	46	53.8%	0.25	2.00	7
Overall	**1.5**	**11.13**	**46**	**57.1%**	**0.25**	**2.11**	**9.25**

Table 7.5 Frequency table of planned project duration

Project duration (month)	Frequency	Percentage	Cumulative percentage
$0 < \text{duration} \leq 3$	14	6.3	6.3
$3 < \text{duration} \leq 6$	56	25.3	31.7
$6 < \text{duration} \leq 9$	46	20.8	52.5
$9 < \text{duration} \leq 12$	38	17.2	69.7
$12 < \text{duration} \leq 18$	44	19.9	89.6
$18 < \text{duration} \leq 24$	13	5.9	95.5
$24 < \text{duration} \leq 36$	9	4.1	99.6
$\text{duration} > 36$	1	0.4	100
Total	221	100.0	

Table 7.6 presents the costs of the case projects. The surveys captured construction projects to the value of £1.4 billions. The value of projects ranged from ten thousands to 120 millions pounds with an average of 6.54 millions. Overall median and mode were two and 16 millions pounds respectively. Evaluation of the frequency table (refer to Table 7.7) revealed that half of the case projects were valued up to 2 millions pounds and eighty percent were valued less than ten millions pounds. These indicate that the size of case projects varied from small to very large projects with most being quite large (63 percent of

case projects valued more than one million pounds). Forty eight percent of case projects were overbudget. Almost similar percentages were found for each type of respondent. Overbudget ranged between two thousands to 16 millions pounds, with an average of 660 thousands pounds.

Table 7.6 Project cost (in £ millions)

Respondent	Value of projects Captured by survey	Tender sum			% of projects which overbudget	Overbudget cost		
		Min	Average	Max		Min	Average	Max
Client	483.4	0.01	6.53	86	42.1%	0.002	1.05	16
Architect	655.3	0.08	9.78	120	52.2%	0.010	0.77	14.4
Contractor	293.0	0.05	3.76	26	49.4%	0.010	0.27	2
Overall	**1,431.7**	**0.01**	**6.54**	**120**	**47.7%**	**0.002**	**0.66**	**16**

Findings from Tables 7.4 and 7.6 suggest that the size of case projects included in this research varied and, on average, were relatively quite large. It is worth noting that two-thirds of the case projects were overbudget and/or overrun, and approximately 40 percent were overrun and overbudget. These findings indicate that, in general, the UK construction industry still suffers from poor performance in terms of cost and time.

Table 7.8 shows type of client involved in the case projects. In general, local authorities were dominant and accounted for nearly half of the clients involved in the case projects. Similar tendencies were found across different respondents. In clients' responses, sixty percent of clients were local authorities. Industrial clients were absent in the clients' case projects.

Table 7.7 Frequency table of tender sum

Tender sum (millions)	Frequency	Percentage	Cumulative percentage
0 < tender sum ≤ 0.5	54	24.7	24.7
0.5 < tender sum ≤ 1	27	12.3	37.0
1 < tender sum ≤ 1.5	19	8.7	45.7
1.5 < tender sum ≤ 2	10	4.6	50.2
2 < tender sum ≤ 4	37	16.9	67.1
4 < tender sum ≤ 6	19	8.7	75.8
6 < tender sum ≤ 10	11	5.0	80.8
10 < tender sum ≤ 15	10	4.6	85.4
15 < tender sum ≤ 20	15	6.8	92.2
20 < tender sum ≤ 50	14	6.4	98.6
tender sum > 50	3	1.4	100
Total	219	100.0	

Table 7.8 Types of client

Respondent	Local authority	Retailer	Financial Institution	Industrial	Property developer	No. case projects
Client	46 59.7%	13 16.9%	5 6.5%	0 0.0%	13 16.9%	77
Architect	26 38.2%	10 14.7%	5 7.4%	17 25.0%	10 14.7%	68
Contractor	31 40.3%	8 10.4%	10 13.0%	19 24.7%	9 11.7%	77
Overall	**103** **46.4%**	**31** **14.0%**	**20** **9.0%**	**36** **16.2%**	**32** **14.4%**	**222**

Table 7.9 presents methods of contractor selection used in the case projects based on clients' and architects' responses. Here, methods of contractor selection included competitive tendering, two-stage competitive tendering, and negotiation. Two-stage

competitive tendering is a variant of competitive tendering which places some consideration on technical competency rather than full reliance on tender sum. Negotiation is a method of engagement based on the relationship between the client and the contractor who jointly negotiate an agreed sum and a specified performance to be delivered. Negotiation particularly fits for relationship-based procurement routes, i.e. partnering and strategic alliances. The results revealed that competitive tendering was still the dominant method of contractor selection. This was followed by the negotiation method. Two-stage competitive tendering was the least popular method. These indicate that while traditional competitive tendering is still used extensively, the use of negotiation is emerging to become an alternative method of contractor selection.

Table 7.9 Methods of contractor selection

Respondent	Competitive tendering	Two stage comp. tendering	Negotiation	No. case projects
Client	53 68.8%	8 10.4%	16 20.8%	77
Architect	34 53.1%	12 18.8%	18 28.1%	64
Overall	**87** **61.7%**	**20** **14.2%**	**34** **24.1%**	**141**

Table 7.10 exhibits methods of contractor payment used in the case projects based on clients' and architects' responses. In this research, methods of contractor payment included lump sum, unit price, and cost reimbursement. Methods of contractor payment influence risk sharing between clients and contractors which ultimately may influence performance and satisfaction levels. The results revealed that lump sum was the most popular payment method. This was followed by unit price and the least, cost reimbursement.

Table 7.10 Methods of contractor payment

Respondent	Lump sum	Unit price	Cost reimbursement	No. case projects
Client	49 65.3%	14 18.7%	12 16.0%	75
Architect	46 71.9%	11 17.2%	7 10.9%	64
Overall	**95** **68.3%**	**25** **18.0%**	**19** **13.7%**	**139**

7.3 RELATIONSHIPS BETWEEN THE CHARACTERISTICS OF THE CASE PROJECTS

This section aims to explore the relationships between the characteristics of the case projects (independent variables) described in the last section. The conceptual relationships between these variables is depicted in a matrix (refer to Table 7.11). Sixty-six possible relationships have been identified as represented by cells in the upper half of the matrix (separated by a diagonal). All but six relationships whose results could be meaningfully interpreted were included in the analysis (as indicated in the matrix). The statistical techniques adopted to explore these relationships are described in the following.

7.3.1 Statistical Techniques

There were two variable types in the independent variables considered, namely nominal and interval. To explore the relationship between two nominal variables, the chi-square test was used, whereas to explore the relationship between nominal and interval variables, the Kruskal-Wallis and Mann-Whitney tests were used. In addition to these, Pearson correlation coefficients were used to explore the relationships between two interval

Table 7.11 Matrix depicting relationships of significant independent variables

Variables	Type of project	Type of building	Proc. route	Planned duration	Project overrun	Overrun duration	Tender sum	Project overbudget	Overbudget cost	Contractor selection	Contractor payment	Type of client
Type of project			●	●	●	●	●	●	●	●	●	
Type of building			●	●	●	●	●	●	●	●	●	
Procurement Route				●	●	●	●	●	●	●	●	●
Planned duration					●	●		●	●	●	●	●
Project overrun							●	●	●	●	●	●
Overrun duration							●	●	●	●	●	●
Tender sum								●	●	●	●	●
Project overbudget										●	●	●
Overbudget cost										●	●	●
Contractor selection											●	●
Contractor payment												●
Type of client												

Note: Dot simbol means analysed relationship variables. Chi-square and Kruskal-Wallis / Mann-Whitney tests are discussed in the following sections.

7.3.1.1 Chi-square test

Chi-square tests are used to confirm whether there is an association between two nominal variables (Siegel, 1956; Bryman and Cramer, 1999; Kinnear and Gray, 1999). These tests are widely used in conjunction with cross-tabulations or contingency tables which are the analogue of the scatterplots (Kinnear and Gray, 1999). The null hypothesis to be tested is that there is no association between two variables. The rejection of the null hypothesis by means of chi-square, only establishes the existence of a statistical association (i.e. it does not measure its strength). Moreover, the chi-square statistic is unsuitable as a measure of association since it is affected by the total frequency (Kinnear and Gray, 1999).

To provide an indicator of the strength of association, several measures, such as phi coefficient and Cramer's V, have been proposed. While phi coefficient is more suitable for 2×2 table (each variable has two categories), Cramer's V is preferred with more complex tables because it can still achieve its maximum value of unity and is therefore deemed more accurate (Kinnear and Gray, 1999). Cramer's V measure of association is identical to the correlation coefficient which has a maximum value of 1 for perfect association and a value of 0 for no association.

The accuracy of chi-square tests is influenced by expected frequencies in the cells of the contingency tables. If any of the expected frequencies is less than 1, or more than 20 percent of the cells have expected frequencies less than 5, the chi-square test is suspect. Cochran (1954 cited in Siegel, 1956) recommended that adjacent categories be combined to increase the expected frequencies in the various cells. However, these adjacent categories must have a common property or mutual identity in order to meaningfully interpret the outcome. Another alternative is to exclude columns and/or rows which have very few expected frequencies. Although this alternative was also adopted here, the excluded columns and/or rows were kept to a minimum. This derives a corrected value of chi-square which is considered more valid.

7.3.1.2 Kruskal-Wallis and Mann-Whitney tests

Kruskal-Wallis and Mann-Whitney tests were used as alternatives to analysis of variance (ANOVA) and *t*-test because preliminary analysis failed to meet parametric assumptions (i.e. normal distribution and constant variance). Kruskal-Wallis and Mann-Whitney tests work on the same principle, except that the Kruskall-Wallis test can be used to compare scores in more than two groups. These tests were more powerful than the median test because it uses more of the information in the observations by converting the scores into ranks rather than simply dichotomising them as above and below the median (Siegel, 1956; Bryman and Cramer, 1999). In other words, Kruskal-Wallis and Mann-Whitney tests preserve the magnitude of the scores more fully than does the median test (Siegel, 1956). Kruskal-Wallis and Mann-Whitney tests are the most efficient of the non-parametric tests. Compared with the most powerful parametric test, ANOVA, they have efficiency of 95.5 percent (Andrew, 1954 cited in Siegel, 1956).

In the computation of these tests, each of the observations is replaced by ranks. That is, all scores from all categories are combined and ranked in a single series. The smallest score is replaced by rank 1, the next to the smallest by rank 2, and so on. Then, the ranks in each category are summed. These tests determine whether these sums of ranks are so disparate that they are not likely to have come from samples which were drawn from the same population. The null hypothesis is that there is no difference in the scores between categories.

When ties occur between two or more scores, each score is given the mean of the ranks for which it is tied (Siegel, 1956). Here, Kruskal-Wallis and Mann-Whitney's statistics have to be corrected. The effect of correcting for ties is to increase the value of statistics and therefore to make the result more significant than it would have been if uncorrected.

7.3.2 Findings and Discussions

This section presents and discusses the findings following investigation of the relationships among significant independent variables. This section is divided into seven sub-sections. All tables of statistically significant findings are presented here. In addition to these, several tables of statistically insignificant findings are also presented, as these are considered to be relatively important. All other tables of statistically insignificant results are presented in Appendix F.

7.3.2.1 The relationships between type of client and the other variables

Table 7.12 presents the investigation of the influence of type of client on procurement route selected. There was a significant association between the choice of procurement route and type of client. Local authorities relied extensively on the use of the traditional procurement route. Moreover, the traditional route was also used more frequently by financial institutions, industrial clients and property developers than other routes. It is worth mentioning that partnering was rarely employed in the public sector. It seems that the public sector find it difficult to justify the use of such value adding routes, possibly because of the need to appear financially accountable for their decisions (Holt *et al.*, 2001). Apart from this, private clients (including retailers, financial institutions, industrialists, and property developers) demonstrated that they had adopted partnering on a significant number of projects. Clients from the retail sector used partnering extensively. Perhaps, this links to the nature of retail building projects which may demand a high degree of uniformity and repetition and as such demand contractors who are familiar with clients' requirements. Furthermore, retail clients need to be confident of project delivery, which may be improved when working closer with the supply chain, as provided by partnering.

Table 7.12 Nature of client business versus procurement route

Nature of client business	Procurement route				Row total
	Traditional	Design and build	Partnering	Const. management	
Local authority	81 78.6%	14 13.6%	6 5.8%	2 1.9%	103 100%
Retailer	12 38.7%	5 16.1%	14 45.2%	0 0.0%	31 100%
Financial institution	11 55.0%	3 15.0%	6 30.0%	0 0.0%	20 100%
Industrial	15 41.7%	9 25.0%	11 30.6%	1 2.8%	36 100%
Property developer	16 50.0%	7 21.9%	8 25.0%	1 3.1%	32 100%
Column total Percentage	135 60.8%	38 17.1%	45 20.3%	4 1.8%	222 100%

Pearson Chi-Square = 37.993 (Cramer's V = 0.239); probability < 0.0005
Cells with expected frequency < 5 = 7 of 20 (35%)
*Based on corrected table (see Appendix F, Table F1.1)
Pearson Chi-Square = 36.397 (Cramer's V = 0.289); probability < 0.0005

The results of Kruskal-Wallis test (refer to Table 7.13) revealed a significant relationship between the type of client and planned project duration indicating that a particular type of client tended to be engaged in projects whose duration was significantly longer or shorter than other clients. The relationship was further scrutinised using Mann-Whitney tests to investigate the difference between types of client (refer to Table 7.14). Results revealed that retailers tended to be engaged in significantly shorter projects than local authorities, industrial clients, and property developers. In addition to this, local authorities had significantly shorter project duration than property developers. Retail projects commonly involve shop-fitting and refurbishment works involving prefabricated materials and methods and therefore their durations tend to be shorter than those of other projects.

Table 7.13 The results of Kruskal-Wallis test to investigate the relationship between type of client and planned project duration

Type of client	Frequency	Mean rank
Local authority	99	104.66
Retailer	31	79.18
Financial institution	20	111.20
Industrial	35	123.63
Property developer	32	133.95
Total	217	

Chi-square = 14.539, $p = 0.006$

Table 7.14 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between type of client and planned project duration

Type of client	Loc. authority	Retailer	Financial inst.	Industrial	Property dev.
Local authority		**0.044**	0.700	0.115	**0.020**
Retailer			0.146	**0.002**	**0.001**
Financial inst.				0.580	0.313
Industrial					0.345
Property dev.					

Note: Number in bold indicates significant relationship

Table 7.15 investigates the relationship between type of client and project overrun. The results revealed significant association between type of client and project overrun suggesting that a particular type of client was more likely to have their project overrun than other clients. Local authorities and financial institutions were more likely to have project overrun than other clients. Retailers were the most unlikely to have project overrun. Although there was an association between type of client and project overrun, there was no association between type of client and overrun duration (Kruskal-Wallis test, $p = 0.856$, Appendix F, Table F1.2).

Table 7.15 Type of client versus project overrun

Type of client	Time outcome		Row total
	On or before schedule	Overrun	
Local authority	30 29.4%	72 70.6%	102 100%
Retailer	20 64.5%	11 35.5%	31 100%
Financial Institution	7 35.0%	13 65.0%	20 100%
Industrial	20 57.1%	15 42.9%	35 100%
Property developer	16 50.0%	16 50.0%	32 100%
Column total Percentage	93 42.3%	127 57.7%	220 100%

Pearson Chi-Square = 17.587 (Cramer's V = 0.283); probability = 0.001
Cells with expected frequency < 5 = 0 of 10 (0%)

There was a significant relationship between type of client and tender sum (refer to Table 7.16). The relationship was further explored using Mann-Whitney tests (refer to Table 7.17). The value of local authority contracts was significantly lower than the value of other clients' contracts. Additionally, industrial clients' contracts were significantly less than those of property developers.

Table 7.16 The results of Kruskal-Wallis test to investigate the relationship between type of client and tender sum

Type of client	Frequency	Mean rank
Local authority	99	81.32
Retailer	30	127.93
Financial institution	20	119.57
Industrial	35	120.39
Property developer	31	152.47
Total	215	

Chi-square = 39.215, $p < 0.0005$

Table 7.17 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between type of client and tender sum

Type of client	Loc. authority	Retailer	Financial inst.	Industrial	Property dev.
Local authority		**0.000**	**0.032**	**0.001**	**0.000**
Retailer			0.766	0.674	0.062
Financial inst.				0.896	0.224
Industrial					**0.014**
Property dev.					

Note: Number in bold indicates significant relationship

Although there was no association between type of client and project overbudget (Pearson Chi-Square = 4.961, p = 0.291, Appendix F, Table F1.3), there was a significant relationship between type of client and overbudget cost as demonstrated by the Kruskal-Wallis test (p = 0.015) presented in Table 7.18. The total number of clients included was about a half of all cases since only those that experienced overbudget were included in the analysis. Further scrutiny using Mann-Whitney tests in Table 7.19 revealed that there were significant differences between overbudget costs of local authority's projects and those of retailers as well as property developers. Overbudget cost of local authority's projects were significantly less than those of retailers and property developers. Perhaps, this reflects the well-known emphasis of public clients to deliver cost certainty rather than time certainty (see previous paragraph on the relationship between type of client and project overrun, also Table 7.15).

Table 7.18 The results of Kruskal-Wallis test to investigate the relationship between type of client and overbudget cost

Type of client	Frequency	Mean rank
Local authority	50	39.64
Retailer	10	63.40
Financial institution	7	52.50
Industrial	17	53.24
Property developer	12	63.96
Total	96	

Chi-square = 12.278, $p = 0.015$

Table 7.19 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between type of client and overbudget cost

Type of client	Loc. authority	Retailer	Financial inst.	Industrial	Property dev.
Local authority		**0.016**	0.201	0.053	**0.016**
Retailer			0.329	0.257	0.741
Financial inst.				0.975	0.236
Industrial					0.162
Property dev.					

Note: Number in bold indicates significant relationship

There was a significant association between type of client and method of contractor selection (refer to Table 7.20). While local authorities showed strong reliance on competitive tendering as a principal method of contractor selection, retailers, financial institutions and property developers showed some preference to negotiation rather than other methods. Almost half of the industrial clients used competitive tendering. These findings indicate that competitive tendering is still very popular in the public sector. Private clients have now started to shift to 'softer' methods such as negotiation.

Table 7.20 Nature of client business versus method of contractor selection

Nature of client business	Method of contractor selection			Row total
	Competitive tendering	Two-stage comp. tend.	Negotiation	
Local authority	60 84.5%	7 9.9%	4 5.6%	71 100%
Retailer	7 31.8%	5 22.7%	10 45.5%	22 100%
Financial institution	3 30.0%	3 30.0%	4 40.0%	10 100%
Ihdustrial	7 46.7%	3 20.0%	5 33.3%	15 100%
Property developer	9 40.9%	2 9.1%	11 50.0%	22 100%
Column total Percentage	86 61.4%	20 14.3%	34 24.3%	140 100%

Pearson Chi-Square = 39.245 (Cramer's V = 0.529); probability < 0.0005
Cells with expected frequency < 5 = 6 of 15 (40%)
*Based on corrected table (see Appendix F, Table F1.4)
Pearson Chi-Square = 34.070 (Cramer's V = 0.533); probability < 0.0005

There was no association between type of client and method of contractor payment (Pearson Chi-Square = 5.447, $p = 0.244$, Appendix F, Table F1.6).

7.3.2.2 The relationships between procurement route and the other variables

Table 7.21 explores the relationship between procurement route and type of project. The chi-square test confirmed that there was a significant difference between the use of procurement route on types of project ($p = 0.003$). While traditional and partnering routes showed a similar pattern of utilisation on type of project, design and build was used extensively in new build projects. Construction management showed a similar utilisation pattern as design and build, however the number of case projects were too few and therefore, this was not conclusive.

Table 7.21 Procurement route versus type of project

Procurement route	Type of project			Row total
	New build	Refurbishment	Extension to existing premises	
Traditional	71 52.2%	45 33.1%	20 14.7%	136 100%
Design and build	35 89.7%	2 5.1%	2 5.1%	39 100%
Partnering	27 60.0%	12 26.7%	6 13.3%	45 100%
Const. Management	4 80.0%	0 0.0%	1 20.0%	5 100%
Column total Percentage	137 60.9%	59 26.2%	29 12.9%	225 100%

Pearson Chi-Square = 20.074 (Cramer's V = 0.211); probability = 0.003
Cells with expected frequency < 5 = 3 of 12 (25%)
*Based on corrected table (see Appendix F, Table F2.1)
Pearson Chi-Square = 18.103 (Cramer's V = 0.203); probability = 0.001

Table 7.22 presents a cross-tabulation exploring the relationship between procurement route and type of building. There was a significant difference between the use of different procurement route on types of building ($p < 0.0005$). Traditional procurement route was used quite extensively in public buildings. Design and build was used more frequently in industrial buildings. These buildings are typically less complex than other types of buildings and therefore the use of design and build is probably the best choice. Partnering was used more frequently in office and retail buildings.

Table 7.22 Procurement route versus type of building

Procurement route	Type of building					Row total
	Public	Office	Retail	Residential	Industrial	
Traditional	61 45.2%	33 24.4%	6 4.4%	26 19.3%	9 6.7%	135 100%
Design and build	8 20.5%	8 20.5%	5 12.8%	7 17.9%	11 28.2%	39 100%
Partnering	8 17.8%	14 31.1%	13 28.9%	2 4.4%	8 17.8%	45 100%
Const. Management	2 40.0%	3 60.0%	0 0.0%	0 0.0%	0 0.0%	5 100%
Column total Percentage	79 35.3%	58 25.9%	24 10.7%	35 15.6%	28 12.5%	224 100%

Pearson Chi-Square = 51.551 (Cramer's V = 0.277); probability < 0.0005
Cells with expected frequency < 5 = 8 of 20 (40%)
*Based on corrected table (see Appendix F, Table F2.2)
Pearson Chi-Square = 46.488 (Cramer's V = 0.326); probability < 0.0005

The Kruskal-Wallis test (refer to Table 7.23) revealed a significant relationship between procurement route and planned project duration (p = 0.049). The mean rank demonstrated that construction management tended to be used for longer projects than the other routes did. The Kruskal-Wallis test was then performed on traditional, design and build, and partnering. The results showed no relationship between these routes and planned project duration (p = 0.202) indicating that the planned duration on case projects using these routes was the same. However, Mann-Whitney tests showed a difference between planned project duration of construction management, and traditional as well as partnering (refer to Table 7.24). Here, the representativeness of case projects using construction management may be suspect.

Although there was a significant relationship between procurement route and project overrun (Table 7.25, Chi-square test, p < 0.0005), there was no relationship between procurement route and project overrun duration (Kruskal-Wallis test, p = 0.665, Appendix

F, Table F2.3). The significant association between procurement route and project overrun indicates that the use of different procurement routes may result in different time performance. For case projects using the traditional procurement route, 70 percent were overrun. In contrast, for case projects using partnering, almost three-quarters were delivered on or before schedule. For projects using design and build, the outcomes were almost equally divided.

Table 7.23 The results of Kruskal-Wallis test to investigate the relationship between procurement route and planned project duration

Procurement route	Frequency	Mean rank
Traditional	133	104.88
Design and build	38	125.74
Partnering	45	109.87
Cons. Management	5	172.00
Total	221	

Chi-square = 7.852, $p = 0.049$

Table 7.24 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between procurement route and planned project duration

Procurement route	Traditional	Design and build	Partnering	Cons. management
Traditional		0.065	0.678	**0.025**
Design and build			0.325	0.106
Partnering				**0.030**
Cons. Management				

Note: Number in bold indicates significant relationship

The Kruskal-Wallis test showed significant association between the procurement route and tender sum indicating that tender sums of a particular procurement route were significantly lower or higher than those of other routes (refer to Table 7.26). The traditional route seemed to have lower tender values than others which was confirmed by the Mann-Whitney test (refer to Table 7.27).

Table 7.25 Procurement route versus project overrun

Procurement route	Time outcome		Row total
	On or before schedule	Overrun	
Traditional	41 30.4%	94 69.6%	135 100%
Design and build	20 51.3%	19 48.7%	39 100%
Partnering	33 73.3%	12 26.7%	45 100%
Const. Management	2 40.0%	3 60.0%	5 100%
Column total Percentage	96 42.9%	128 57.1%	225 100%

Pearson Chi-Square = 26.809 (Cramer's V = 0.346); probability < 0.0005
Cells with expected frequency < 5 = 2 of 8 (25%)
*Based on corrected table (see Appendix F, Table F2.4)
Pearson Chi-Square = 26.782 (Cramer's V = 0.350); probability < 0.0005

Table 7.26 The results of Kruskal-Wallis test to investigate the relationship between procurement route and tender sum

Procurement route	Frequency	Mean rank
Traditional	131	90.45
Design and build	39	133.65
Partnering	44	142.10
Cons. Management	5	155.30
Total	219	

Chi-square = 31.762, $p < 0.0005$

Table 7.27 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between procurement route and tender sum

Procurement route	Traditional	Design and build	Partnering	Cons. management
Traditional		**0.000**	**0.000**	**0.034**
Design and build			0.471	0.375
Partnering				0.519
Cons. management				

Note: Number in bold indicates significant relationship

Although there was significant relationship between procurement route and project overbudget (Table 7.28, Chi-square test, $p = 0.003$), there was no relationship between procurement route and overbudget cost (Kruskal-Wallis test, $p = 0.180$, Appendix F, Table F2.5). Results revealed that more than half of the case projects using the traditional route were overbudget, while three-quarters of those using partnering were on or under budget. Moreover, more than a- half of those using design and build were on or under budget.

Table 7.28 Procurement route versus project overbudget

Procurement route	Cost outcome		Row total
	On or under budget	Overbudget	
Traditional	61 45.5%	73 54.5%	134 100%
Design and build	21 53.8%	18 46.2%	39 100%
Partnering	33 75.0%	11 25.0%	44 100%
Const. Management	1 20.0%	4 80.0%	5 100%
Column total Percentage	116 52.3%	106 47.7%	222 100%

Pearson Chi-Square = 13.683 (Cramer's V = 0.248); probability = 0.003
Cells with expected frequency < 5 = 2 of 8 (25%)
*Based on corrected table (see Appendix F, Table F2.6)
Pearson Chi-Square = 11.568 (Cramer's V = 0.231); probability =0.003

Investigation of the relationships between procurement route and time and cost outcomes of case projects were very interesting, suggesting that the use of different procurement routes may arrive at different project outcomes. For projects using the traditional procurement route, 70 percent were overrun and more than a-half were overbudget. In contrast, for partnering, three-quarters were on or before schedule and on or under budget. For projects using design and build, the outcomes were almost equally divided into two. In terms of time and cost performance, these findings suggest partnering produces significantly better outcomes than other procurement routes.

There was a significant association between procurement route and method of contractor selection (Table 7.29, Chi-square test, $p < 0.0005$). Furthermore, Cramer's V measure of association indicates a very high association (0.738). Almost all of the case projects using the traditional route utilised competitive tendering to select contractors. Three-quarters of case projects using partnering chose their contractor by negotiation. Design and build case projects relied predominantly on both competitive and two-stage competitive tendering (approximately 40 percent each).

There was a significant association between procurement route and method of contractor payment ($p < 0.0005$) as presented in Table 7.30. Traditional and design and build case projects relied heavily on the lump sum method of contractor payment. Partnering case projects shifted their reliance on lump sum to cost reimbursement which was considered a 'softer' (i.e. less adversarial) payment method.

Table 7.29 Procurement route versus method of contractor selection

Procurement route	Method of contractor selection			Row total
	Competitive tendering	Two-stage comp. tender.	Negotiation	
Traditional	75 87.2%	5 5.8%	6 7.0%	86 100%
Design and build	8 38.1%	9 42.9%	4 19.0%	21 100%
Partnering	3 9.7%	5 16.1%	23 74.2%	31 100%
Const. Management	1 33.3%	1 33.3%	1 33.3%	3 100%
Column total Percentage	87 61.7%	20 14.2%	34 24.1%	141 100%

Pearson Chi-Square = 85.278 (Cramer's V = 0.550); probability < 0.0005
Cells with expected frequency < 5 = 5 of 12 (42%)
*Based on corrected table (see Appendix F, Table F2.7)
Pearson Chi-Square = 64.731 (Cramer's V = 0.738); probability < 0.0005

Table 7.30 Procurement route versus method of contractor payment

Procurement route	Method of contractor selection			Row total
	Lump sum	Unit price	Cost reimbursement	
Traditional	63 75.0%	17 20.2%	4 4.8%	84 100%
Design and build	18 85.7%	2 9.5%	1 4.8%	21 100%
Partnering	12 40.0%	6 20.0%	12 40.0%	30 100%
Const. Management	2 50.0%	0 0.0%	2 50.0%	4 100%
Column total Percentage	95 68.3%	25 18.0%	19 13.7%	139 100%

Pearson Chi-Square = 32.228 (Cramer's V = 0.340); probability < 0.0005
Cells with expected frequency < 5 = 6 of 12 (50%)
*Based on corrected table (see Appendix F, Table F2.8)
Pearson Chi-Square = 29.048 (Cramer's V = 0.328); probability < 0.0005

7.3.2.3 The relationships between method of contractor selection and the other variables

The relationship between method of contractor selection and type of project is demonstrated in Table 7.31. The chi-square test revealed a significant association between the method of contractor selection and project type (p = 0.049). While negotiation was used quite extensively in new build projects, it was not well utilised in refurbishment and extensions in comparison with competitive and two-stage competitive tendering.

Table 7.31 Method of contractor selection versus type of project

Method of contractor Selection	Type of project			Row total
	New build	Refurbishment	Extension to existing premises	
Competitive tendering	51 58.6%	28 32.2%	8 9.2%	87 100%
Two-stage competitive tendering	10 50.0%	5 25.0%	5 25.0%	20 100%
Negotiation	27 79.4%	5 14.7%	2 5.9%	34 100%
Column total Percentage	88 62.4%	38 27.0%	15 10.6%	141 100%

Pearson Chi-Square = 9.843 (Cramer's V = 0.187); probability = 0.043
Cells with expected frequency < 5 = 2 of 9 (22%)
*Based on corrected table (see Appendix F, Table F3.1)
Pearson Chi-Square = 6.035 (Cramer's V = 0.207); probability = 0.049

Table 7.32 shows a cross-tabulation investigating the relationship between method of contractor selection and type of building. There was a significant association between method of contractor selection and type of building (p = 0.003). Competitive tendering was used quite extensively in public building projects. Two-stage competitive tendering was used more frequently in retail projects. Negotiation was used more frequently in office projects and less utilised in public building projects.

Table 7.32 Method of contractor selection versus type of building

Method of contractor Selection	Type of building					Row total
	Public	Office	Retail	Residential	Industrial	
Competitive tendering	44 50.6%	22 25.3%	3 3.4%	10 11.5%	8 9.2%	87 100%
Two-stage competitive tendering	6 30.0%	2 10.0%	7 35.0%	3 15.0%	2 10.0%	20 100%
Negotiation	4 11.8%	14 41.2%	8 23.5%	4 11.8%	4 11.8%	34 100%
Column total Percentage	54 38.3%	38 27.0%	18 12.8%	17 12.1%	14 9.9%	141 100%

Pearson Chi-Square = 31.887 (Cramer's V = 0.336); probability < 0.0005
Cells with expected frequency < 5 = 6 of 15 (40%)
*Based on corrected table (see Appendix F, Table F3.2)
Pearson Chi-Square = 15.822 (Cramer's V = 0.335); probability = 0.003

The Kruskal-Wallis tests revealed no significant relationships between method of contractor selection and planned project duration ($p = 0.634$, Appendix F, Table F3.3) and project overrun duration ($p = 0.776$, Appendix F, Table F3.4) respectively. However, there was a significant relationship between method of contractor selection and project overrun ($p = 0.001$) as shown in Table 7.33. It is worth noting that a significant percentage of case projects using competitive tendering were overrun. In contrast, almost 70 percent of case projects using negotiation were completed on or before schedule. Case projects using two-stage competitive tendering were slightly better than those using competitive tendering. This suggests that in terms of time performance, the negotiation method of contractor selection produces better outcomes than competitive methods.

The Kruskal-Wallis test presented revealed a significant relationship between method of contractor selection and tender sum (refer to Table 7.34, $p < 0.0005$). Subsequent Mann-Whitney tests indicated a significant difference between tender sums using competitive tendering and those using the other two methods of contractor selection (refer to Table

7.35). Competitive tendering tended to be used in smaller contracts than the other two methods.

Table 7.33 Method of contractor selection versus project overrun

Method of contractor Selection	Time outcome		Row total
	On or before schedule	Overrun	
Competitive tendering	25 29.1%	61 70.9%	86 100%
Two-stage competitive tendering	8 40.0%	12 60.0%	20 100%
Negotiation	23 67.6%	11 32.4%	34 100%
Column total Percentage	56 40.0%	84 60.0%	140 100%

Pearson Chi-Square = 15.109 (Cramer's V = 0.329); probability = 0.001
Cells with expected frequency < 5 = 0 of 6 (0%)

Although there was a significant association between method of contractor selection and project overbudget (refer to Table 7.36, p = 0.050), there was no association between method of contractor selection and overbudget cost (Kruskal-Wallis test, p = 0.141, Appendix F, Table F3.5). Table 7.36 shows that more than half of the case projects using competitive tendering were overbudget. In contrast, seventy percent of case projects using negotiation were on or under budget. The cost outcome for two-stage competitive tendering was mediocre with case projects almost equally divided into overbudget or otherwise. This provided further evidence of the poor performance of such traditional methods of project procurement.

Table 7.34 The results of Kruskal-Wallis test to investigate the relationship between method of contractor selection and tender sum

Method of contractor selection	Frequency	Mean rank
Competitive tendering	84	55.80
Two-stage comp. tend.	20	91.82
Negotiation	33	88.77
Total	137	

Chi-square = 24.099, $p < 0.0005$

Table 7.35 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between method of contractor selection and tender sum

Method of contractor selection	Competitive tendering	Two-stage comp. tend.	Negotiation
Competitive tendering		**0.000**	**0.000**
Two-stage comp. tend.			0.720
Negotiation			

Note: Number in bold indicates significant relationship

Table 7.36 Method of contractor selection versus project overbudget

Method of contractor Selection	Cost outcome		Row total
	On or under budget	Overbudget	
Competitive tendering	39 45.9%	46 54.1%	85 100%
Two-stage competitive tendering	11 55.0%	9 45.0%	20 100%
Negotiation	24 70.6%	10 29.4%	34 100%
Column total Percentage	74 53.2%	65 46.8%	139 100%

Pearson Chi-Square = 5.984 (Cramer's V = 0.207); probability = 0.050
Cells with expected frequency < 5 = 0 of 6 (0%)

Table 7.37 exhibits a cross-tabulation exploring the relationship between methods of contractor selection and payment. Results revealed a significant relationship between these two ($p < 0.0005$). While lump sum was the most popular payment method, cost reimbursement was used quite often on negotiated case projects. Cost reimbursement may be regarded as a 'softer' method of contactor payment where the financial risk is shifted to the client. However, this demands a high level of trust between the client and the contractor since client deems that contractor will not abuse this.

Table 7.37 Method of contractor selection versus method of contractor payment

Method of contractor Selection	Method of contractor payment			Row total
	Lump sum	Unit price	Cost reimbursement	
Competitive tendering	64 75.3%	17 20.0%	4 4.7%	85 100%
Two-stage competitive tendering	14 70.0%	4 20.0%	2 10.0%	20 100%
Negotiation	17 51.5%	4 12.1%	12 36.4%	33 100%
Column total Percentage	95 68.8%	25 18.1%	18 13.0%	138 100%

Pearson Chi-Square = 21.248 (Cramer's V = 0.277); probability < 0.0005
Cells with expected frequency < 5 = 3 of 9 (33%)
*Based on corrected table (see Appendix F, Table F3.6)
Pearson Chi-Square = 20.357 (Cramer's V = 0.415); probability < 0.0005

7.3.2.4 The relationships between method of contractor payment and the other variables

There was no association between method of contractor payment and type of project (Chi-square test, $p = 0.102$, Appendix F, Table F4.2) and type of building (Table 7.38; Chi-square test, $p = 0.182$) respectively. For the latter, however, there was a significant association between these where method of contractor payment includes only lump sum and cost reimbursement (Table 7.38; Chi-square test, $p = 0.048$). Cost reimbursement tended to be used in office and retail building projects. Perhaps, this is linked to the extensive use of partnering and negotiation in office and retail building projects (see sections 7.3.2.2 and 7.3.2.3).

Table 7.38 Method of contractor payment versus type of building

Method of contractor Payment	Type of building					Row total
	Public	Office	Retail	Residential	Industrial	
Lump sum	38 40.0%	27 28.4%	10 10.5%	14 14.7%	6 6.3%	95 100%
Unit price	10 40.0%	7 28.0%	2 8.0%	2 8.0%	4 16.0%	25 100%
Cost reimbursement	4 21.1%	5 26.3%	5 26.3%	1 5.3%	4 21.1%	19 100%
Column total Percentage	52 37.4%	39 28.1%	17 12.2%	17 12.2%	14 10.1%	139 100%

Pearson Chi-Square = 11.358 (Cramer's V = 0.202); probability = 0.182
Cells with expected frequency < 5 = 6 of 15 (40%)
*Based on corrected table (see Appendix F, Tables F4.3 and F4.4)
Method of contractor payment included lump sum and unit price
Pearson Chi-Square = 3.029 (Cramer's V = 0.159); probability = 0.553
Method of contractor payment included lump sum and cost reimbursement
Pearson Chi-Square = 9.568 (Cramer's V = 0.290); probability = 0.048

There was no relationship between method of contractor payment and project planned duration (Kruskal-Wallis test, p = 0.976, Appendix F, Table F4.5), overrun (Chi-square test, p = 0.345) and overrun duration (Kruskal-Wallis test, p = 0.869, Appendix F, Table F4.6). Subsequent analysis of the cross-tabulation Table 7.39 indicates that cost reimbursement may perform better than lump sum and unit price although this was not significant.

The Kruskal-Wallis test (refer to Table 7.40) revealed a significant relationship between method of contractor payment and tender sum (p = 0.015). Subsequent Mann-Whitney tests (refer to Table 7.41) revealed that tender sums of case projects using the cost reimbursement method were significantly larger than those of case projects using lump sum or unit price methods.

Table 7.39 Method of contractor payment versus project overrun

Method of contractor Payment	Time outcome: On or before schedule	Time outcome: Overrun	Row total
Lump sum	34 35.8%	61 64.2%	95 100%
Unit price	11 44.0%	14 56.0%	25 100%
Cost reimbursement	10 52.6%	9 47.4%	19 100%
Column total Percentage	55 39.6%	84 60.4%	139 100%

Pearson Chi-Square = 2.129 (Cramer's V = 0.124); probability = 0.345
Cells with expected frequency < 5 = 0 of 6 (0%)

Table 7.40 The results of Kruskal-Wallis test to investigate the relationship between method of contractor payment and tender sum

Method of contractor payment	Frequency	Mean rank
Lump sum	94	65.97
Unit price	23	57.78
Cost reimbursement	18	91.67
Total	135	

Chi-square = 8.414, $p = 0.015$

Table 7.41 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between method of contractor payment and tender sum

Method of contractor payment	Lump sum	Unit price	Cost reimbursement
Lump sum		0.386	**0.012**
Unit price			**0.004**
Cost reimbursement			

Note: Number in bold indicates significant relationship

There was no relationship between method of contractor payment and project overbudget (Chi-square test, $p = 0.493$) and overbudget cost (Kruskal-Wallis test, $p = 0.145$, Appendix F, Table F4.7) respectively. Analysis of the cross-tabulation Table 7.42 showed that in term of cost performance, the unit price method of payment was better than lump sum and cost reimbursement methods. However, this was not significant.

Table 7.42 Method of contractor payment versus project overbudget

Method of contractor Payment	Cost outcome		Row total
	On or under budget	Overbudget	
Lump sum	46 48.9%	48 51.1%	94 100%
Unit price	15 62.5%	9 37.5%	24 100%
Cost reimbursement	10 52.6%	9 47.4%	19 100%
Column total Percentage	71 51.8%	66 48.2%	137 100%

Pearson Chi-Square = 1.415 (Cramer's V = 0.102); probability = 0.493
Cells with expected frequency < 5 = 0 of 6 (0%)

7.3.2.5 The relationships between type of project and time and cost variables

There was a significant relationship between type of project and planned project duration as revealed by the Kruskal-Wallis test ($p < 0.0005$) presented in Table 7.43. Mann-Whitney tests (refer to Table 7.44) further revealed that planned durations of new build projects were significantly different from those of the other two project types. New build projects had significantly longer durations than the other two project types, which was as expected.

Table 7.43 The results of Kruskal-Wallis test to investigate the relationship between type of project and planned project duration

Type of project	Frequency	Mean rank
New build	132	128.52
Refurbishment	59	78.06
Extension to existing premises	29	94.48
Total	220	

Chi-square = 27.921, $p < 0.0005$

Table 7.44 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between type of project and planned project duration

Type of project	New build	Refurbishment	Extension to existing premises
New build		**0.000**	**0.007**
Refurbishment			0.180
Extension to existing premises			

Note: Number in bold indicates significant relationship

There was no relationship between type of project and project overrun (Chi-square test, p = 0.369, Appendix F, Table F5.1) and overrun duration (Kruskal-Wallis test, p = 0.668, Appendix F, Table F5.2) respectively.

The Kruskal-Wallis test revealed a significant relationship between type of project and tender sum (refer to Table 7.45, $p < 0.0005$). Mann-Whitney tests (refer to Table 7.46) further revealed that tender sums of new build projects were significantly different from those of the other two project types. New build projects had significantly greater tender sums than the other two project types as was expected.

Table 7.45 The results of Kruskal-Wallis test to investigate the relationship between type of project and tender sum

Type of project	Frequency	Mean rank
New build	133	127.75
Refurbishment	57	75.69
Extension to existing premises	28	91.63
Total	218	

Chi-square = 29.763, $p < 0.0005$

Table 7.46 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between type of project and tender sum

Type of project	New build	Refurbishment	Extension to existing premises
New build		**0.000**	**0.004**
Refurbishment			0.155
Extension to existing premises			

Note: Number in bold indicates significant relationship

There was no relationship between type of project and project overbudget (Chi-square test, $p = 0.704$, Appendix F, Table F5.3) and overbudget cost (Kruskal-Wallis test, $p = 0.259$, Appendix F, Table F5.4) respectively.

7.3.2.6 The relationships between type of building and time and cost variables

There was a significant relationship between type of building and planned project duration as confirmed by the Kruskal-Wallis test ($p < 0.0005$) presented in Table 7.47. Subsequent Mann-Whitney tests (refer to Table 7.48) indicates that the duration of office building projects was significantly longer than those of other types of building. The duration of public building projects was shorter than those of office projects and longer than those of retail projects. Furthermore, the duration of retail building projects was shorter than those of industrial projects. Retail building projects tended to have shorter duration than others due to, perhaps, the demands of such clients.

Table 7.47 The results of Kruskal-Wallis test to investigate the relationship between type of building and planned project duration

Type of building	Frequency	Mean rank
Public	76	110.19
Office	58	137.79
Retail	24	73.50
Residential	34	96.46
Industrial	27	99.26
Total	219	

Chi-square = 21.594, $p < 0.0005$

Although there was a significant relationship between type of building and project overrun (Chi-square test, $p = 0.003$), there was no relationship between type of building and overrun duration (Kruskal-Wallis test, p = 0.552, Appendix F, Table F6.1). Table 7.49 presents a cross-tabulation exploring the relationship between type of building and project overrun. It is worth noting that, in term of time performance, retail and industrial building projects performed better than other projects.

Table 7.48 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between type of building and planned project duration

Type of client	Public	Office	Retail	Residential	Industrial
Public		**0.011**	**0.017**	0.266	0.403
Office			**0.000**	**0.001**	**0.004**
Retail				0.070	**0.028**
Residential					0.855
Industrial					

Note: Number in bold indicates significant relationship

Table 7.49 Type of building versus project overrun

Type of building	Time outcome		Row total
	On or before schedule	Overrun	
Public	27 34.6%	51 65.4%	78 100%
Office	27 47.4%	30 52.6%	57 100%
Retail	17 70.8%	7 29.2%	24 100%
Residential	9 25.7%	26 74.3%	35 100%
Industrial	15 53.6%	13 46.4%	28 100%
Column total Percentage	95 42.8%	127 57.2%	222 100%

Pearson Chi-Square = 15.825 (Cramer's V = 0.267); probability = 0.003
Cells with expected frequency < 5 = 0 of 10 (0%)

The results of the Kruskal-Wallis test (refer to Table 7.50) revealed a significant relationship between type of building and tender sum ($p < 0.0005$). Further investigation using Mann-Whitney tests (refer to Table 7.51) demonstrated that tender sums of public building projects were significantly smaller than those of office, retail and industrial building projects, but greater than residential building projects. Furthermore, tender sums of residential building projects were smaller than those of other projects.

Table 7.50 The results of Kruskal-Wallis test to investigate the relationship between type of building and tender sum

Type of building	Frequency	Mean rank
Public	78	91.65
Office	57	139.42
Retail	23	134.15
Residential	33	65.74
Industrial	26	127.02
Total	217	

Chi-square = 40.839, $p < 0.0005$

Table 7.51 Probability matrix presenting the results of Mann-Whitney tests to investigate the relationship between type of building and tender sum

Type of client	Public	Office	Retail	Residential	Industrial
Public		**0.000**	**0.003**	**0.023**	**0.007**
Office			0.530	**0.000**	0.259
Retail				**0.000**	0.616
Residential					**0.000**
Industrial					

Note: Number in bold indicates significant relationship

There was no significant relationship between type of building and project overbudget (Chi-square test, $p = 0.055$) and overbudget cost (Kruskal-Wallis test, $p = 0.057$, Appendix

F, Table F6.2) respectively. However, subsequent analysis of the contingency table (refer to Table 7.52) indicated that in terms of cost performance, retail and industrial building projects were better than the other projects, although this was not significant. Interestingly, this was also coincident with the time performance of building projects where retail and industrial building projects were also better than the other projects (see previous paragraph in this section, also Table 7.49).

Table 7.52 Type of building versus project overbudget

Type of building	Time outcome		Row total
	On or under budget	Overbudget	
Public	36 46.8%	41 53.2%	77 100%
Office	29 50.9%	28 49.1%	57 100%
Retail	18 78.3%	5 21.7%	23 100%
Residential	15 42.9%	20 57.1%	35 100%
Industrial	17 60.7%	11 39.3%	28 100%
Column total Percentage	115 52.3%	105 47.7%	220 100%

Pearson Chi-Square = 9.255 (Cramer's V = 0.205); probability = 0.055
Cells with expected frequency < 5 = 0 of 10 (0%)

7.3.2.7 The relationships among time and cost variables

There was no relationship between planned project duration and project overrun (Mann-Whitney test, $p = 0.687$, Appendix F, Table F7.1), overrun duration (Pearson's correlation coefficient $r = 0.105$, $p = 0.125$), and project overbudget (Mann-Whitney test, $p = 0.929$, Appendix F, Table F7.2) respectively. This suggests that the length / duration of a project has no impact on (i) whether it be delivered on time and on budget, and (ii) the length of any delays incurred during construction. However, there was significant evidence of a relationship between planned duration and overbudget cost (Pearson's correlation coefficient $r = 0.397$, $p < 0.0005$). This means that if a project is overbudget, the amount of overbudget cost will increase as planned duration increases.

The Mann-Whitney test (refer to Table 7.53) revealed a significant relationship between project overrun and tender sum ($p = 0.001$) indicating that projects which overrun tended to have a lower tender sum than projects which were on or before schedule. Perhaps, projects with a greater tender sum are given greater priority and allocated more resources than smaller projects.

Table 7.53 The results of Mann-Whitney test to investigate the relationship between project overrun and tender sum

Time outcome	Frequency	Mean rank
On or before schedule	93	124.96
Overrun	124	97.03
Total	217	

Asymptote significant $p = 0.001$

Table 7.54 presents a contingency table investigating the relationship between project overrun and overbudget. Results showed a significant relationship ($p < 0.0005$) indicating that projects which overrun tended to be overbudget and vice versa. This was fortified by a high value of Cramer's V measure of association (0.468).

Table 7.54 Project overrun versus project overbudget

Time outcome	Cost outcome		Row total
	On or under budget	Overbudget	
On or before schedule	75 78.9%	20 21.1%	95 100%
Overrun	40 31.7%	86 68.3%	126 100%
Column total Percentage	115 52.0%	106 48.0%	221 100%

Pearson Chi-Square = 48.349 (Cramer's V = 0.468); probability < 0.0005
Cells with expected frequency < 5 = 0 of 4 (0%)

The Mann-Whitney test confirmed that there was no relationship between project overrun and overbudget cost (p = 0.664, Appendix F, Table F7.3). This indicates that time performance has no influence upon the extent of the overbudget costs. That is, projects completed overbudget, can include those delivered on or before schedule and those completed behind schedule. Further, for those projects which are completed overbudget, there was no significant difference between the overbudget costs for those completed on or before schedule and those completed behind schedule.

There was no relationship between overrun duration and tender sum (Pearson's correlation coefficient $r = 0.076$, $p = 0.204$) indicating that for projects which overrun, the length of overrun duration did not depend on tender sum. Furthermore, there was also no relationship between overrun duration and project overbudget (Mann-Whitney test, p = 0.095, Appendix F, Table F7.4) and overbudget cost (Pearson's correlation coefficient r = 0.105, p = 0.174) respectively. The former suggests that for projects which overrun, the length of overrun duration is not dependent on whether projects are completed overbudget or otherwise. The latter indicates that for projects which overrun and overbudget, the amount of overbudget cost is not dependent on the length of overrun duration.

The Mann-Whitney test confirmed no relationship between tender sum and project overbudget (Mann-Whitney test, $p = 0.309$, Appendix F, Table F7.5) meaning that all projects regardless the amount of tender sum have a similar probability of being overbudget. However, there was a significant relationship between tender sum and overbudget cost (Pearson's correlation coefficient $r = 0.743$, $p < 0.0005$). This suggests that if projects are overbudget, the greater the tender sum the greater the overbudget cost will be.

7.4 SUMMARY

This chapter has presented and described the descriptive analysis of the case project characteristics (i.e. the independent variables) and the relationships between these variables. The following paragraphs briefly discuss the important findings.

A majority of the case projects were new build and public building (e.g. schools, leisure facilities) projects. Local authorities were the dominant client in this research. The traditional procurement route was employed in the majority of case projects confirming the popularity of this route. Furthermore, data analysis suggests partnering is emerging as a popular alternative to the traditional route. Analysis of time and cost of case projects revealed that the size of case projects were relatively quite large. A significant percentage of the case projects were overrun and/or overbudget. This suggests that, in general, the UK construction industry still suffers from poor performance in terms of cost and time. The results also revealed that competitive tendering was still the dominant method of contractor selection, however negotiation was a popular alternative. The lump sum method of contractor payment was more popular than unit price and cost reimbursement.

Table 7.55 presents a matrix showing the significant / insignificant relationships between independent variables. Chi-square, Kruskal-Wallis, Mann-Whitney and Pearson's correlation tests were used to identify significant relationships. Several important conclusions could be drawn from these are presented in the following paragraphs.

Different types of client tended to choose different procurement routes (e.g. local authorities tended to use the traditional route) which was also found to influence project performance. Partnering and negotiation seemed to outperform the other procurement methods in terms of time and cost performance. The use of such 'softer' methods of project procurement improves performance and as such all clients are advised to consider these methods.

Analysis of the relationship between time and cost variables suggests that the duration of a project has no influence on the likelihood of being overrun and overbudget. However if a project is overbudget, the amount of overbudget cost will increase as planned duration increases. Furthermore, projects which have lower tender sums have a greater probability of being delivered late. Perhaps, more effort is expended on larger projects to ensure time delivery. The results also suggest that projects which overrun tend to be overbudget and vice versa. For projects which are overbudget, the greater the tender sum, the greater the overbudget cost will be.

Table 7.55 Matrix showing significant or insignificant relationships between independent variables

Variables	Type of project	Type of building	Proc. route	Planned duration	Project overrun	Overrun duration	Tender sum	Project overbudget	Overbudget cost	Contractor selection	Contractor payment	Type of client
Type of project			✓	✓	✗	✗	✓	✗	✗	✓	✗	
Type of building			✓	✓	✓	✗	✓	✗	✗	✓	✓	
Procurement Route				✓	✓	✗	✓	✓	✗	✓	✓	✓
Planned duration					✗	✗		✗	✓	✗	✗	✓
Project overrun							✓	✓	✗	✓	✗	✓
Overrun duration							✗	✗	✗	✗	✗	✗
Tender sum								✗	✓	✓	✓	✓
Project overbudget										✓	✗	✗
Overbudget cost										✗	✗	✓
Contractor selection											✓	✓
Contractor payment												✗
Type of client												

Note: Tick simbol means significant relationship, cross simbol means insignificant relationships

The next chapter will discuss the data preparation methods applied prior to model development.

Chapter 8

Data Preparation for Modelling

8.1 INTRODUCTION

Having undertaken the questionnaire survey, the data were then prepared for analysis. First, missing values in the data were investigated and imputation methods to deal with such values were explored and selected. Secondly, systematic variable treatments were conducted, such as multicollinearity and binary (dummy) variables transformation. This was to address data which could not be directly used for analysis. Thirdly, investigation led to the determination of a legitimate satisfaction measure for modelling purposes. This involved the choice of whether to use a single or multiple measures of satisfaction. The principal components analysis technique was applied to derive several satisfaction dimensions based on scores attributed to the performance criteria. These satisfaction measures were also assessed for their validity and reliability. This chapter provides a detailed account of this data preparation.

8.2 MISSING VALUES

Missing values are common in research involving questionnaire surveys. Respondents may be unwilling or unable to respond to some questions, or may fail to complete sections of a questionnaire due to a lack of time or interest. This problem is unintended and uncontrolled by the researcher (Schafer and Olsen, 1998). Here, those variables with substantial missing values were excluded from further analysis (refer to section 6.5.1), however there remained some missing values in the data. The removal of these cases (i.e.

responses) would have substantially reduced the number of useful cases and vitiated the data collection exercise.

As artificial neural network analysis with NeuroSolutions software, requires fully complete data, a method for imputing such data had to be developed. Earlier experiments with incomplete data resulted in a failure to run the analysis. Although this problem has not been addressed in the manuals (NeuroDimension, Inc., 1995a, b, 1999), it was acknowledged as a weakness by one of their principal technicians (NeuroDimension, Inc.) in a conversation with the author. Moreover, the data set used for artificial neural network and multiple regression modelling techniques should be the same.

Table 8.1 shows the percentages of missing values for each assessment case both for independent variables (i.e. attributes) and dependent variables (i.e. criteria). The percentages are considered very small. Norusis (1995, p.48) described how such small percentages do not pose analysis problems and that conclusions drawn are still valid and robust.

Table 8.1 Percentage of missing values

Respondent	Assessment of	Attributes (%)	Criteria (%)
Client	Architect	1.80	1.63
	Contractor	2.07	1.94
Architect	Client	4.24	0.75
	Contractor	2.06	1.73
Contractor	Client	3.35	0.64
	Architect	3.07	1.80

In general, missing values were imputed with estimated mean values. The advantage of this imputation method over other missing values procedures is that standard complete-data methods can be used for further analysis (Bernaards and Sijtsma, 2000). Although this imputation method is not the only method available, its utilisation is simple, practical (Bernaards and Sijtsma, 1999; 2000), and appropriate to this research in light of the small percentages involved. Other methods such as the Expectation-Maximization (EM) algorithm (Dempster, *et al.*, 1977; Little and Rubin, 1987) were considered overly complex. Furthermore, preliminary analysis of the missing values failed to suggest any obvious patterns in the data matrices worthy of further analysis and/or utilisation of more complex methods (Hill, 1997).

While missing values for attributes were imputed using the attributes' mean, those for performance criteria were imputed based on the respondent mean (i.e. person mean). In the use of principal component analysis as in this research, Bernaards and Sijtsma (1999) found that imputation of the person mean across the available scores for that person is the best alternative to Expectation-Maximization (EM). That is, this method best recovers the component loadings structure from the complete data (Bernaards and Sijtsma, 2000). These procedures resulted in fully complete data for analysis purposes.

8.3 INDEPENDENT VARIABLES

This section discusses preparation of the independent variables for analysis. Multicollinearity problems and transformation of binary (dummy) variables are explained in detail.

8.3.1 Multicollinearity in Independent Variables

Before any analysis is conducted, the researcher should fully understand the nature of their data in order to diagnose problems, such as multicollinearity and outliers. Amongst these, the problem of multicollinearity was considered the most serious for data of this nature. Multicollinearity is a data problem, not an analysis problem, where any independent variable is a linear combination of other independent variables. Here, the purpose of data analysis is not only for prediction but also for explanation, in which case, multicollinearity prevents the influence of any variable being separated from other variables which highly explain that variable (i.e. high correlation). One immediate remedy is to increase the sample size. That is, multicollinearity ceases to be a problem when the sample size is increased (Lewis-Beck, 1993). However, large samples are also difficult to obtain given the general poor response rate to surveys.

Another convenient and popular remedy of the multicollinearity problem is to remove the independent variables affected, leaving those which are not collinear with each other. Although this method is convenient, popular and practical (Cheung, 1998), it has been described as an inappropriate and scientifically invalid remedy (Belsley *et al.*, 1980; Berry and Feldman, 1993). This action can severely bias the remaining parameter estimates (Belsley, *ibid.*; Berry and Feldman, *ibid.*). It is admitted that, with non experimental social science data, the independent variables are virtually always intercorrelated (i.e. multicollinear) (Lewis-Beck, *ibid.*). For example, to satisfactorily perform, a contractor should possess good past performance / reputation in cost, time and quality, effective training, quality assurance, and health and safety policies, and employ qualified and capable site personnel. In this research, it would be inappropriate to drop / remove such variables with similar high scores because of multicollinearity. Therefore, another possible remedy for multicollinearity was needed.

One possible and relatively practical strategy is to combine those independent variables that are highly interrelated into a single indicator (Lewis-Beck, *ibid.*; Dunteman, 1994). However, the variables combined should be viewed as indicators of the same theoretical concept and make conceptual sense in order for it to work well (Berry and Feldman, *ibid.*; Lewis-Beck, *ibid.*). For example in contractor attributes, one could consider combining knowledge of local subcontractors with knowledge of local labour into one indicator named 'local supports'.

8.3.1.1 The use of principal components analysis

The principal components analysis (PCA) technique was used to identify which variables could be combined into one indicator as suggested by Dunteman (1994, p.215). When using the PCA, to ensure the analysis is meaningful, the sampling adequacy must be examined. One way to do this is by using the Kaiser-Meyer-Olkin (KMO) measure, which is an index between 0 to 1. Small values for the KMO measure indicate that a PCA of the variables may not be appropriate, since correlations between pairs of variables can not be explained by the other variables (Norusis, 1994, p.52). Values of KMO below 0.5 are unacceptable (Kaiser, 1974 cited in Norusis, *ibid.*, p.53). Higher KMO measures allow more meaningful analysis to be obtained. This can further be confirmed by Bartlett's test of sphericity which tests the null hypothesis that the correlation matrix is an identity matrix (i.e. there is no correlation between criteria) (Norusis, *ibid.*, p. 50). The value of the test statistic for sphericity is based on a chi-square transformation of the determinant of the correlation matrix.

The analysis was conducted on each category of attributes, for example, respondent attributes were analysed independently from participant attributes. This is because, from examination of the correlation matrices, attributes tend to correlate with like attributes (i.e. within the same categories). Their KMO measures were then examined and Bartlett's tests of sphericity conducted. As an example, the PCA of architect performance attributes as assessed by contractors was used. The KMO was 0.749 and the chi-square test was significant ($p < 0.0005$), indicating that PCA could be meaningfully applied.

PCA was used to produce a structure matrix of the variables after rotation. The number of components determined was based on the criterion that the eigen value for each component should be greater than 1 (Torbica, 1997). This method, also known as Kaiser's criterion is considered the most commonly used procedure to determine the number of initial components to be extracted (Kim and Mueller, 1978a). This derived four principal components which explain 68 percent of the variation in the variables (refer to Table 8.2). Another method is to utilize the scree test as suggested by Cattell (1978). Although it was regarded as one of the best solutions for selecting the correct number of components, it was also critisised due to its subjectivity (Kline, 1994; 1998). Here, Kline (1994) suggested to compare the scree test with some other methods such as Kaiser's criterion. The first step of the scree test is to plot the eigen values of the components in descending order (refer to Figure 8.1). Starting at the highest eigen value, the plot is curved at first then develops into a linear relationship about point A. The point at which the curve straightens out is taken as the maximum number to be extracted (Child, 1990; Dunteman, *ibid.*). In this example, the first six components would qualify. The scree test derived two more components than the Kaiser's criterion. These conflicting results are not uncommon given the subjectivity of the criteria, i.e. there are no hard and fast rules to determine number of principal components (Dunteman, *ibid.* p.190). Child (*ibid.*) regarded the Kaiser's criterion to be more conservative (i.e. extracting less components) than the scree test. In fact, in the example, the fifth and sixth components were less than unity (i.e. less than one). This means that components with eigen values less than one contain less information than a single standardised variable whose variance is one (Dunteman, *ibid.*). Therefore, any component with an eigen value smaller than 1 must be of no significance (Kline, 1998). Furthermore, the more principal components relative to the number of variables retained, the less parsimonious description of the data. In addition, smaller principal components (in terms of eigen values) are, in general, harder to interpret than larger ones (Dunteman, *ibid.* p.173). In this example, it was decided to use four principal components.

Table 8.2 Eigen values, percentage and total variance explained

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	**4.796**	**36.896**	**36.896**
2	**1.672**	**12.860**	**49.756**
3	**1.335**	**10.268**	**60.024**
4	**1.014**	**7.800**	**67.824**
5	0.920	7.080	
6	0.708	5.446	
7	0.561	4.313	
8	0.526	4.046	
9	0.489	3.761	
10	0.355	2.728	
11	0.266	2.043	
12	0.213	1.639	
13	0.146	1.120	

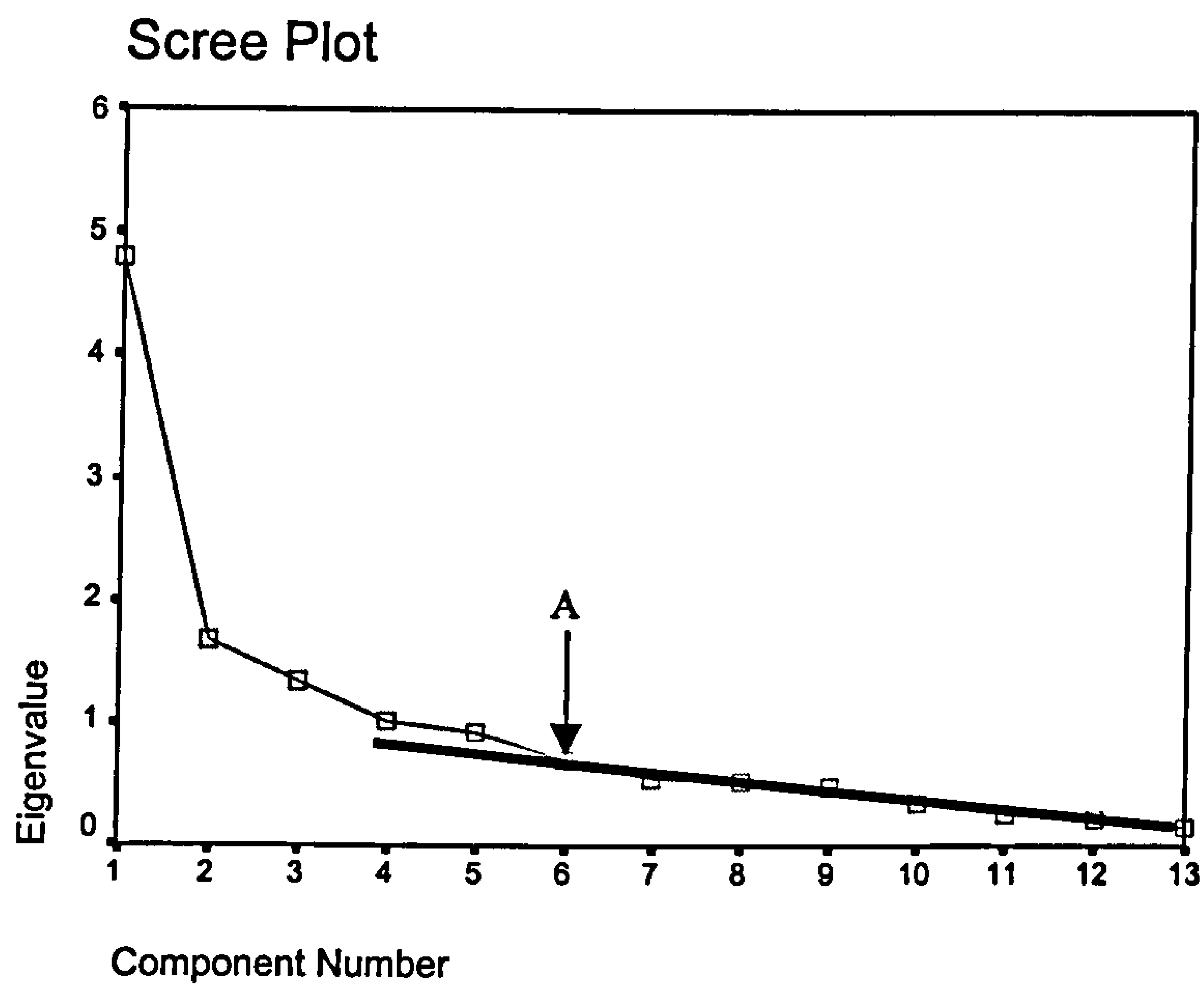


Figure 8.1 Scree plot of components' eigen values based on the PCA of architect performance attributes as assessed by contractors

To achieve the simplest possible structure in order to obtain more interpretable components / dimensions, promax oblique rotation with the power (*Kappa*) valued at 4 was utilised. Oblique rotation (as opposed to orthogonal rotation) was utilised since it allows the presence of correlations between components / dimensions. In fact, this assumption concurs with the real life situation since one aspect of performance should be, to some extent, related to other aspects (Cattell, 1978; Bryman and Cramer, 1999 p.279). Furthermore, Norusis (1994) claimed that oblique rotations have often been found to yield substantively meaningful components since it is likely that influences in nature are correlated.

Promax has a reputation for demonstrable quality as evidenced in empirical studies (Gorsuch, 1983). Promax rotation raises the component loading to a higher power in order that moderate and low loadings need to be lower while the high loadings remain relatively high (Gorsuch, *ibid.*). For example, the original loadings were 0.9 and 0.3. 0.3 is one-third as large as 0.9, but the squared loading for the second variable is 0.09 which is one-ninth as large as the squared loading for the first variable, 0.81. By raising the power of component loadings, the component structure becomes more interpretable. The power is known as the coefficient *Kappa* (*k*). Gorsuch (*ibid.*) recommended that the proper power is that which gives the simplest structure with the least correlation among components. Furthermore, he claimed that a good solution is generally achieved by raising the loadings to a power of four (SPSS default). In this research, *Kappa* = 2 and 6 were trialed, but these did not derive better solutions than *Kappa* = 4.

Table 8.3 depicts the component correlation matrix and shows that the first and second components have a medium level of correlation (r = 0.529). The other correlations were relatively low. This indicates that the presence of four principal components is quite distinct to warranty the appropriate use of PCA (see discussion on section 8.4.2).

Table 8.3 Component correlation matrix

Component	1	2	3	4
1	1.000	0.529	0.114	-0.129
2		1.000	0.216	-0.028
3			1.000	-0.052
4				1.000

Variables showing high loadings (i.e. correlation coefficients) with a component were then combined into one indicator. These variables were averaged (i.e. unweighted). Table 8.4

shows the structure matrix for architect performance attributes identified by contractors. Component loadings of these attributes were observed. The cut-off point for significant component loadings is influenced by the sample size and number of components under consideration. That is, as the number of components increases and the sample size decreases, the value required for significance rises sharply (Child, 1990). As the purpose of the PCA here is to eliminate or reduce multicollinearity, the significance of the problem must be considered. Bryman and Cramer (1999) suggested extremely high correlation coefficient as high as 0.8. In this research, a correlation coefficient of 0.750 was used as a conservative cut-off point. The variables which had more than 0.750 (i.e. bold component loadings) in each component were combined to form new attributes. Those variables whose loadings were below 0.75, were not combined since this level of correlation would not pose serious problem. Combining variables which have medium correlations (which do not cause multicollinearity) simply prevents detailed modelling to be conducted, meaning that individual independent variables' effect on satisfaction levels could not be examined in detail. Two new combined variables were derived, that is the architect's reputation (i.e. past performance) in terms of adherence to schedule and budget (reputation in speed of information delivery and reputation in adherence to budget) and past performance in general and capability of director (past performance in the last project and qualification and experience of director/principal). The PCA of other performance assessment cases are presented in Appendix G.

8.3.2 Dummy Variables

As previously described in section 6.2.2.2, although most variables were collected in the form of continuous (i.e. interval) data, several nominal variables were collected, for example procurement route and type of project. These variables were transformed into dummy variables in which one nominal variable is represented by several binary dummy variables in the form of 0 or 1 ('no' or 'yes'). Each dummy variable captures one piece of the categorical information from the original measure. Here, the information in the original variables is not fundamentally altered, instead an alternative form of representing that information is chosen (Hardy, 1993). Therefore, these variables do not cause the regression estimates to lose any of their desirable properties (Lewis-Beck, 1993). Furthermore, Hardy (*ibid.*) claimed that as long as the interpretation of regression coefficients is consistent with the underlying measurement properties of the independent variables, the use of binary dummy variables is statistically solid.

Table 8.4 Structure matrix of principal component analysis of architect performance attributes

Attributes	**Component**			
	1	**2**	**3**	**4**
Current workload				0.887
Financial soundness		0.688		
Experience in the type of project		0.644		
Experience in the size of project	0.515	0.681		
Past performance in the last project	0.662	**0.752**		
Reputation in speed of information delivery	**0.897**	0.536		
Reputation in adherence to budget	**0.873**			
Reputation in design quality	0.586	0.529		
Reputation in litigation			0.813	
Qualification and experience of director/principal		**0.758**	0.506	
Qualification and experience of project architect	0.642			-0.700
Quality assurance system	0.691			
Previous working relationship between contractor and architect			0.556	

Note: KMO = 0.749
Chi-square = 283.999 (degree of freedom = 78; $p < 0.0005$)
Loadings less than 0.5 were suppressed

It has also been found that independent variables used in regression analysis can include any combination of binary dummy and interval variables (Hardy, *ibid.*; Lewis-Beck, *ibid.*). The artificial neural network technique can also deal with binary and interval variables as input variables at the same time (Edwards, 1999).

While most transformation techniques use (*C*-1) dummy variables to represent *C* categories in order to avoid perfect multicollinearity, Dorsett and Webster (1983) and Kvanli *et al.* (1996) claimed that, in a forward or stepwise regression procedure (as used here), it is perfectly acceptable to use *C* dummy variables to represent *C* categories. Here, this method was used to transform nominal variables into binary dummy variables.

8.4 DEPENDENT VARIABLES

This section explains the development and treatment of the dependent variable (i.e. the satisfaction measure) and also the methods used to test its validity and reliability. First, the selection of an appropriate satisfaction measure is explained and justified. Methods to determine a legitimate satisfaction measure for modelling purposes are then described, followed by tests performed to confirm its validity and reliability.

8.4.1 Which Satisfaction Measure for Modelling?

In this research, satisfaction is measured using an interval scale (i.e. scale 0-10) which assumes that satisfaction is a matter of degree, not an all or no property. The expressed satisfaction levels implicitly included the importance levels of each criterion (Mobley and Locke, 1970). Furthermore, it has typically been found that the sum of the weighted scores does not predict ratings of overall satisfaction (e.g. job satisfaction in the field of psychology) any better than the sum of unweighted satisfaction ratings (Decker, 1955; Ewen, 1967; Schaffer, 1953; Mikes and Hulin, 1968 cited in Mobley and Locke, 1970).

Here, the object of measurement is a particular participant's satisfaction as derived from the performance of others. Two possible measures of satisfaction were included in the questionnaire. First, respondents were asked to gauge their satisfaction levels against a wide range of performance criteria, and secondly against one overall measure of satisfaction. The question therefore is which measure is the most legitimate for modelling purposes? That is, whether to use multiple or a singular measures of satisfaction as dependent variable.

Literature suggests the use of multiple measures because of their validity and reliability (e.g. Nunnally, 1978; Johnson and Fornell, 1991; Torbica, 1997). However, where multiple measures are used, these should demonstrate some distinction between each other to demonstrate that they are in fact measuring different aspects of satisfaction. This can be tested through the use of statistical analysis such as principal component analysis (Nunnally, 1978). Notwithstanding this, a single measure provides several advantages including its simplicity, parsimony and therefore convenience. The development of an appropriate measure is presented in the following section.

8.4.1.1 Derivation of multiple satisfaction measures

The principal components analysis (PCA) technique was applied to the performance criteria of those responses (i.e. case projects) used for developing the models. As an example, the PCA of the scores of contractor performance criteria derived from architect's assessments was used. The analysis utilized 54 responses. The main purpose was to determine the number of common components (i.e. satisfaction dimensions) that would satisfactorily produce the correlations among the observed variables (Kim and Mueller, 1978b). This method allows for data reduction and is considered as a means of exploring interdependence of variables. The procedure is similar to that explained in section 8.3.1.1.

Table 8.5 shows the number of principal components retained based on the Kaiser's criterion. Six components were retained explaining 81 percent of the variation of the variables. Figure 8.2 shows the scree plot of eigen values of the components. Based on Cattell's scree test, ten components should be retained. Due to the reasons explained in section 8.3.1.1, six components were used. An examination of eigen values suggests that there is only a single dominant component, that is the first component which explains 64 percent variation of the variables.

Table 8.5 Eigen values, percentage and total variance explained

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	30.775	64.114	64.114
2	2.318	4.830	68.943
3	1.948	4.059	73.002
4	1.388	2.891	75.894
5	1.305	2.718	78.612
6	1.152	2.400	81.011
7	0.998	2.079	
8	0.919	1.914	
9	0.816	1.700	
10	0.664	1.384	

Note: Components 11-48 are not shown

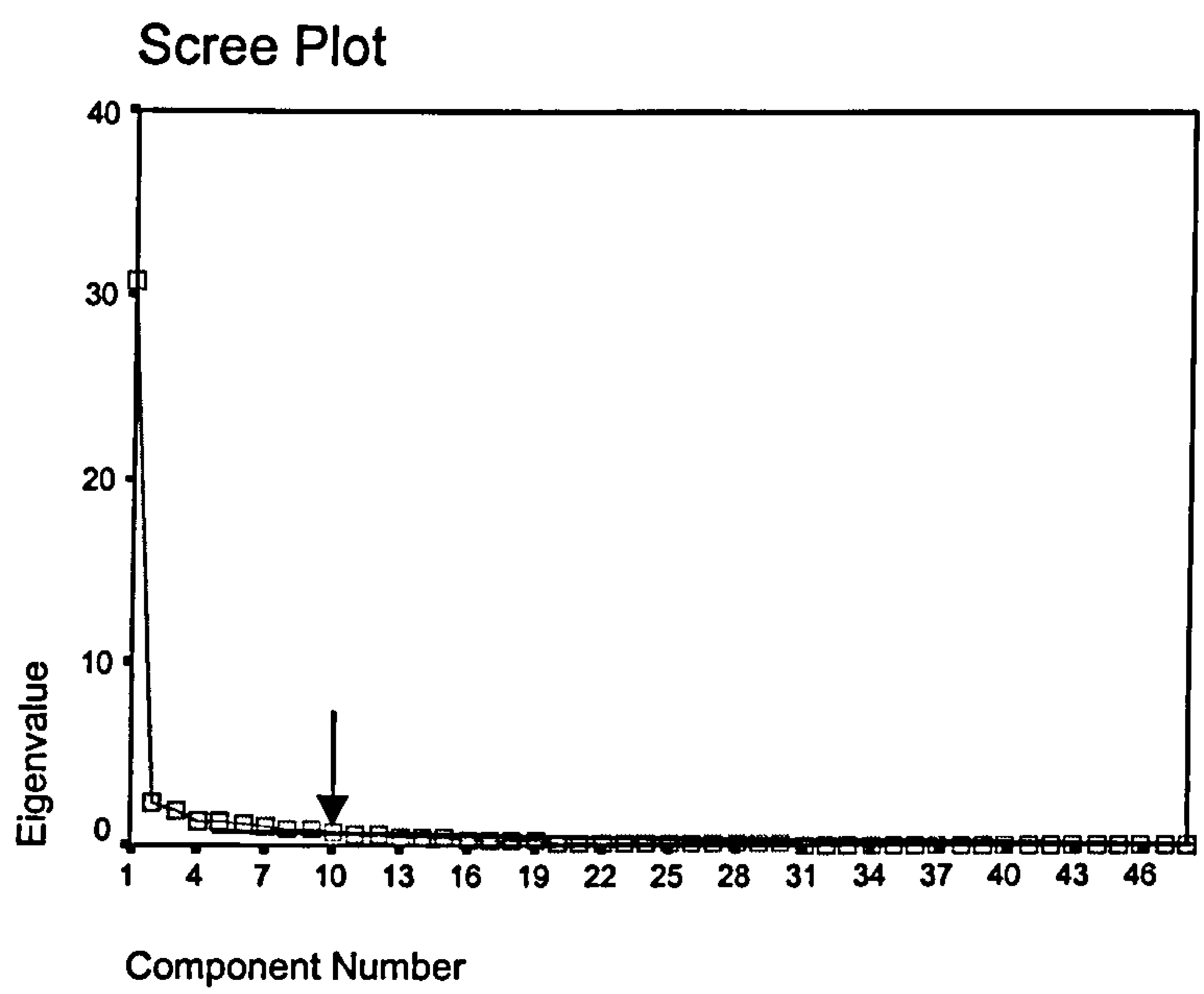


Figure 8.2 Scree plot of components' eigen values based on the PCA of the scores of contractor performance criteria derived from architect's assessments

Table 8.6 depicts the component correlation matrix. Medium to high intercorrelations among components 1 to 4 could be observed suggesting that the presence of the first four components could not be clearly separated.

Table 8.6 Component correlation matrix

Component	1	2	3	4	5	6
1	1.000	**0.796**	**0.596**	**0.563**	0.177	0.233
2		1.000	**0.570**	**0.524**	0.111	0.150
3			1.000	**0.438**	0.068	0.195
4				1.000	0.010	0.357
5					1.000	-0.311
6						1.000

Table 8.7 presents the component structure matrix, which indicates the relationship between the performance criteria and the component. The matrix (columns 3-8) was examined to identify the performance criteria for each component / dimension. An attempt was conducted to obtain performance criteria within each component / dimension. Each dimension consists of several performance criteria, which have highest component loadings on that dimension. Performance criteria that had their second highest component loadings within 0.10 of their highest ones were not used to define any dimension (i.e. deleted) (Torbica, *ibid.*). This is because these criteria do not uniquely contribute to any dimension (Kim and Mueller, 1978a).

The scores of the performance criteria under each dimension were then averaged to obtain the satisfaction measure (i.e. component score). As an example in Table 8.7, from the original 48 performance criteria, 25 were allocated to a particular component. Criteria coded V2, V3, C1, C2, C3, C4, C5, M1, M2, Q3, Q4, Q5, Q8, A8 were included in satisfaction measure-1 (*satis1*). Since this measure contains several criteria commonly used to assess contractor performance, it was named '*main contractor performance criteria*'. *Satis2* consisted of S1, S2, E1, E2, E3, E4 indicating '*performance of site personnel*'. *Satis3* included S4, S5 representing '*adherence to regulations*'. Criteria coded P3, P4, P5 were included in *satis4* indicating '*performance in preliminary stage*'. *Satis5* and *satis6* were not used because they included only one criteria in each dimension which their reliability was questionable (Nunnally, 1978). Additionally, two further measures were derived from the mean of *satis1* to *satis4* (*avesat*), and the overall satisfaction of contractor performance derived from one question in the questionnaire (*totsat*).

Table 8.7 Component structure matrix of contractor performance criteria

Contractor Performance Criteria	Code	Satisfaction Measures					
		satis1	*satis2*	*satis3*	*satis4*	*satis5*	*satis6*
Pre-construction Stage							
~ First interview and presentation	P1			0.621	0.552		
~ Ability and willingness to help develop brief	P2					0.811	
~ Contribution to design and buildability of project	P3				0.732	0.528	
~ Plan of work and method statement	P4	0.569			0.871		
~ Understanding of contract and specifications	P5	0.595	0.539	0.515	0.899		
Construction Stage							
Site management							
~ Site supervision and control	S1	0.716	0.844	0.652	0.610		
~ Site organisation, tidiness and cleanliness	S2	0.668	0.838	0.734	0.532		
~ Ability to plan and programme properly	S3	0.860	0.848	0.645	0.709		
~ Health and safety performance / management	S4	0.552	0.597	0.907			
~ Compliance to regulations (CDM, etc.)	S5	0.639	0.665	0.915			
Resource management							
~ Material management	R1	0.709	0.713	0.764	0.652		
~ Man power management (sufficient quantity and quality of craftsmen	R2	0.795	0.795	0.632	0.574		
~ Equipment and plant management	R3	0.676	0.768	0.686			
~ Management and co-ordination of subcontractors and suppliers	R4	0.795	0.818	0.664	0.690		
~ Payment to subcontractors and suppliers (on time)	R5	0.672	0.745				
~ Strength of contractor site team (i.e. quantity)	R6	0.799	0.769	0.648			
~ Concern/awareness for environmental issues	R7	0.721	0.552	0.759	0.503		
Site personnel							
~ Cooperation with client (i.e. client representative)	E1	0.661	0.853				
~ Individual performance and ability	E2	0.755	0.949	0.545			
~ Project manager performance and adequacy of authority	E3	0.779	0.892	0.506			
~ Site manner (i.e. no loud noises and swearing)	E4	0.558	0.775		0.502		
Variations and drawings							
~ Processing variations (e.g. speed, flexibility)	V1	0.729	0.800		0.658		
~ Preparation of shop drawings and as-built drawings	V2	0.833	0.636		0.557		
~ Contribution to development of design drawings	V3	0.778	0.527			0.556	
Completion Stage & Ease of Delivery							
~ Completion of defects	C1	0.829	0.651	0.637			
~ Smoothness of operation and hand-over	C2	0.901	0.708	0.619			
~ Quality of hand-over document (O&M manual, H&S)	C3	0.789	0.623	0.504			
~ Ease / speed of settlement of final account	C4	0.826	0.635		0.533		
~ Ease of delivery (general feeling on how things went)	C5	0.920	0.787	0.622	0.569		
Principal							
~ Adherence to schedule (time performance)	M1	0.934	0.763	0.620	0.591		
~ Adherence to budget (cost performance)	M2	0.928	0.804	0.647	0.626		
~ Quality of construction and workmanship	M3	0.861	0.835	0.676	0.692		
Quality of Service							
~ Handling of complaints (effectiveness)	Q1	0.769	0.776	0.687			
~ Telephone inquiries and correspondence handled courteously and adequately	Q2	0.830	0.906	0.553	0.528		
~ Speed and reliability of service	Q3	0.927	0.777	0.619	0.628		
~ Responsiveness to architects' queries	Q4	0.914	0.786		0.654		
~ Ability to make rapid decisions	Q5	0.895	0.738		0.531		
~ Commitment of key person (active & continuous)	Q6	0.816	0.778	0.514			
~ Corporate hospitality	Q7						0.724
~ Administration	Q8	0.851	0.680	0.586	0.593		
Attitude							
~ Honesty and integrity	A1	0.815	0.824	0.631	0.574		
~ Collaborative / spirit of cooperation / team work	A2	0.835	0.897	0.630	0.601		
~ Customer focus / proactive to understand architect	A3	0.886	0.851	0.517	0.582		
~ Keep the architect informed	A4	0.897	0.807	0.562	0.563		
~ Communication (to coalition member & site person)	A5	0.864	0.875	0.571	0.640		
~ Pro-active attitude toward problems	A6	0.888	0.822	0.513	0.512		
~ Avoidance of claims (i.e. not claims conscious)	A7	0.729	0.737		0.574		
~ Responsibility for their decision (understand the cost of his recommendation)	A8	0.882	0.726		0.551		

Note: Loadings less than 0.5 were suppressed

In general, the stability (and hence the reliability) of the PCA solution is affected by sample size (Bryman and Cramer, 1999; Gorsuch, *ibid.*; Kim and Mueller, 1978b). There are diverse opinions regarding what constitutes a sufficient sampling size. Generally, there are no strict rules applied for this purpose (Bryman and Cramer, *ibid.*; Gorsuch, *ibid.*; Kim and Mueller, *ibid.*). However, the consensus is that sample size should be more than the number of variables (i.e. performance criteria) (Bryman and Cramer, *ibid.*) as in all performance assessment cases in this research.

8.4.1.2 Justification of the use of a single satisfaction measure for modelling

Several satisfaction measures have been derived. However, their use as dependent variables in the modelling must be justified to represent the expressed satisfaction levels of assessors. Examination of the eigen values and component correlation matrix indicates that this is most likely to be a single satisfaction measure (refer to section 8.4.1.1). Furthermore, Table 8.8 shows high intercorrelations among the various satisfaction measures. This suggests that satisfaction is not a multidimensional concept, at least in the context of this research based on the information from the data obtained. Here, the data indicate that satisfaction is a singular concept which can be represented by one satisfaction measure. The question therefore is which satisfaction measure is the most appropriate.

The overall satisfaction of contractor performance derived from one question in the questionnaire (*totsat*) seemed to be an eligible measure. *Totsat* is unique because it represents an individual (i.e. generic) satisfaction score as expressed by architects in this example. Although individual scores may be less valid and reliable than combined scores (Nunnally, 1978), *totsat* provides an immediate measure of satisfaction levels which is useful for the principle of parsimony. Most importantly, *totsat* has demonstrated extremely

Table 8.8 Correlation matrix of satisfaction measures

		satis1	*satis2*	*satis3*	*satis4*	*avesat*	*totsat*	*repeat work*
satis1	r	1.000	*0.800*	*0.623*	*0.670*	*0.915*	**0.887**	**0.832**
	Sig. (1-tailed)		0.000	0.000	0.000	0.000	0.000	0.000
satis2	r		1.000	*0.661*	*0.556*	*0.891*	**0.900**	**0.814**
	Sig. (1-tailed)			0.000	0.000	0.000	0.000	0.000
satis3	r			1.000	*0.475*	*0.810*	**0.635**	**0.573**
	Sig. (1-tailed)				0.000	0.000	0.000	0.000
satis4	r				1.000	*0.784*	**0.618**	**0.627**
	Sig. (1-tailed)					0.000	0.000	0.000
avesat	r					1.000	**0.898**	**0.841**
	Sig. (1-tailed)						0.000	0.000
totsat	r						1.000	**0.873**
	Sig. (1-tailed)							0.000
repeat work	r							1.000
	Sig. (1-tailed)							
Average '*italic*' or 'bold'		*0.719* (average of 10 correlation coefficients)					**0.788**	**0.737**

Note: r = Pearson correlation coefficient
N = number of samples = 54
The coefficient alpha = 0.9774 (for 25 criteria included to measure satisfaction)

high levels of correlation with the other satisfaction measures, the lowest being 0.618 and the highest being 0.900 (refer to Table 8.8). By and large, the development of several models based on the various satisfaction measures (*satis1* to *satis4* and *avesat*) will derive relatively similar results as from that based on *totsat* alone.

Another area of concern is the intercorrelations among the principal components. One may contend the legitimacy of this procedure for obtaining an empirical measure of satisfaction. Regarding this, Nunnally (*ibid.*) stated:

> "Since usually it is necessary to combine scores on a number of variables to obtain valid measures of constructs, some method is required for determining the legitimacy of forming particular combinations. Important in determining this legitimacy are the patterns of correlations among variables."

This suggests correlations among the variables are fundamental to valid PCA in which variables (i.e. performance criteria) should correlate highly with each other within a particular component and less correlate with the other variables in the other components / dimensions. High correlations between variables in any particular component indicate that the variables basically measure the same thing. In this research, it would seem that variables in one component are also highly correlated with variables in other components (refer to Table 8.8). Although the degree of correlations among variables within one component may be slightly higher than that among variables between components, the results do not appear adequately distinct to warrant some sort of separation. Furthermore, Nunnally (*ibid.*) advocated that one must suspect PCA which derives high correlation among oblique axes (refer to Table 8.6) which can lead to questionable conclusions about the overall results of the analysis.

The above reasons led to the decision to employ overall satisfaction (*totsat*) as the principal measure of satisfaction. The other performance assessment cases tended to show similar results (see Appendix H) and therefore it was decided to use *totsat* as a measure of satisfaction in all cases. With regard to the validity and reliability of this measure of satisfaction, references were made to the various measures of satisfaction as derived from the PCA and are now discussed.

8.4.2 Validity of the Satisfaction Measure

The validity of a measurement instrument concerns the extent to which it measures what it purports to measure (Bohrnstedt, 1970; Carmines and Zeller, 1979). Here, the instrument was intended to measure satisfaction. Therefore, the relationship between satisfaction and the operational definition of satisfaction (i.e. performance criteria) should be strong. To obtain a complete understanding of the validity of the performance criteria, three types of validity were tested, namely content validity, criterion-related validity (concurrent validity) and construct validity (Bohrnstedt, *ibid.*; Carmines and Zeller, *ibid.*; Nunnally, *ibid.*). Here, an assessment was made of the satisfaction measures including *satis1* to *satis4* and *avesat*. Because *totsat* was used as the dependent variable in the modelling, its relationship with the other satisfaction measures and its validity (i.e. construct validity) were emphasized.

8.4.2.1 Content validity

Content validity depends on the extent to which an empirical measurement reflects a specific domain of content (Carmines and Zeller, *ibid.*). Content validity concerns the comprehensiveness of the instrument in representing the abstract concept. Carmines and Zeller (*ibid.*) suggested a thorough literature review in the subject domain as a means of establishing content validity. However, Oliver (1997) recommended that, in cases, where little other basis for discovering performance criteria is available, the interview approach is recommended. Interviews provided a robust and authentic main source of information as considered in this research and thereby provided the content validity of the measurement instrument. Additionally, the results of the interviews were also supported by literature review.

Carmines and Zeller (*ibid.*) further highlighted that it is impossible to specify exactly how many items need to be included for any particular domain of content. However, they suggested that it is always preferable to construct too many items rather than too few since inadequate items can always be excluded, but the researcher is rarely in a position to add 'good' items at a later stage in the research when the original pool of such items is inadequate.

Content validity as a method of assessing the validity of social science measures has been criticised for its reliance on subjective judgement (Bohrnstedt, *ibid.*; Cronbach and Meehl, 1955 cited in Carmines and Zeller, *ibid.*; Nunnally, *ibid.*). Although, the performance criteria were developed from extensive interviews with practitioners and also supported by literature review (i.e. fulfilling content validity), this alone is not fully sufficient for assessing the validity of a measurement instrument. Therefore, the validity of the instrument was further assessed using criterion-related and construct validity.

8.4.2.2 Criterion-related validity

Criterion-related validity becomes an issue when the purpose of using an instrument is to estimate some important form of behaviour that is external to the measuring instrument itself, the latter being referred to as the criterion (Nunnally, *ibid.*). The degree of criterion-related validity is usually estimated by the size of correlation between the instrument and the criterion (Carmines and Zeller, *ibid.*). A moderate correlation of 0.3 or 0.4 is sufficiently valid since people are too complex to ensure high correlations between measures (Nunnally, *ibid.*).

Carmines and Zeller (*ibid.*) proposed two types of criterion-related validity, i.e. concurrent and predictive validity. While concurrent validity is assessed by correlating a measure and the criterion at the same point in time, predictive validity concerns a future criterion which is correlated with the relevant measure. They further highlighted that the logic and procedures are the same for both concurrent and predictive validity, the only difference is the current or future existence of the criterion variable.

This research adopted concurrent validity based on the present existence of the criterion. *Totsat* was validated using various satisfaction measures. In the example in Table 8.8, the results provided an average correlation of 0.788 thereby confirming the criterion-related validity. This average correlation also shows that *totsat* were highly related with the satisfaction measures.

8.4.2.3 Construct validity

Construct validity is concerned with the extent to which a particular measure relates to other measures consistent with theoretically derived hypotheses concerning concepts (or constructs) that are being measured (Carmines and Zeller, *ibid.*). They further stated that the construct validity of empirical measurement could be assessed if the measure can be placed in a theoretical context. If the measure consistently performs in accordance with theoretically derived expectations, it can be concluded that the measure is construct valid.

Customer satisfaction, particularly in the field of marketing research, is theoretically closely related to customer loyalty. Sargent (2000), a director of a marketing information firm (J.D. Power and Associates), found that in every other industry analysed, such as mobile telephones, airlines, electric utilities, and real estate and home building, there was generally a powerful association between consumer satisfaction and intended consumer loyalty. In this research, satisfaction was theoretically related to '*potential for repeat work*' (i.e. loyalty) (Brown and Swartz, 1989; Johnson and Fornell, 1991; Fornell, 1992; Anderson *et al.*, 1994; Oliver, 1997). This was valid since the respondents were experienced practitioners regularly involved in the construction process. Although one may argue that, for example from the architects' point of view, repeat works may also be related to financial aspects since they are service providers, their willingness to embark in future projects with the same participants reflects, to some extent, the satisfaction derived from working with such participants on previous projects. To assess the construct validity of the measuring instrument, *totsat* were correlated with the expressed levels of '*potential for repeat work*' with the same participants. Results demonstrate high levels of correlation between *totsat* and the potential for repeat work confirming the construct validity of *totsat*

(Pearson's correlation coefficient, $r = 0.873$, $p < 0.0005$). This justifies the use of *totsat* as the dependent variable in the modelling.

8.4.3 Reliability of Satisfaction Measure

Reliability focuses on the extent to which a measuring instrument provides consistent results across repeated measurements (Bohrnstedt, *ibid.*; Carmines and Zeller, *ibid.*; Nunnally, *ibid.*). Carmines and Zeller (*ibid.*) claimed that the measurement of any phenomenon always contains a certain amount of chance error since error-free measurement is never attained in any area of scientific investigation. Therefore, an amount of chance error is universally present to some extent. The exact reliability of a measuring instrument can not be determined, instead it can only be estimated (Bohrnstedt, *ibid.*; Torbica, *ibid.*). This is partly because the true score of measurement is the result of an infinite number of repeated measurements, which can not be obtained in real life.

There are four basic methods for estimating the reliability of measuring instruments. They are the retest method, the alternative-form method, the split-halves method and the internal consistency method (Carmines and Zeller, *ibid.*). Here, the internal consistency method was used because it requires only a single test administration and it provides a unique estimate of reliability. There are three coefficients for estimating reliability, i.e. alpha, theta and omega. Coefficient Cronbach's alpha, which provides a conservative estimate of a measure's reliability (i.e. alpha < theta < omega), was used here. This is also because of the practicality and robustness of alpha as an estimate of reliability (Carmines and Zeller, *ibid.*; Nunnally, *ibid.*). While Carmines and Zeller (*ibid.*) advocated that alpha should not be lower than 0.80, Nunnally (*ibid.*) suggested that alpha should not be below 0.70. In the example in Table 8.8, coefficient alpha for the satisfaction measures with 25 criteria is 0.9774. This indicates that the satisfaction measures are highly reliable.

Although combined scores may be more valid and reliable than individual scores alone (Nunnally, 1978), the use of overall satisfaction (*totsat*) was justifiable because it has demonstrated a high degree of correlation with highly reliable satisfaction measures. This high correlation, in fact, could be deemed as evidence of the reliability of *totsat*.

8.4 SUMMARY

This chapter has described the preparation of data for statistical modelling. First, the methods used to deal with missing values have been explained and justified, followed by the treatment of multicollinearity problems, and transforming nominal scaled variables into binary dummy variables. Preparation of dependent variables included the investigation of legitimate satisfaction measure(s) to be used as dependent variables in the modelling. The validity and reliability tests performed on these measures have also been explained. Results confirmed the legitimacy of overall satisfaction (*totsat*) to be used as the dependent variable. The validity and reliability of *totsat* were also justified with reference to several other satisfaction measures which demonstrated very high levels of correlation. The next chapter will discuss the modelling techniques used to relate independent and dependent variables.

Chapter 9

Modelling Techniques

9.1 INTRODUCTION

This chapter discusses the modelling techniques used to develop the satisfaction models. In essence, the techniques were used to relate the independent variables with each dependent variable (i.e. satisfaction measure). First, the two techniques used are described in detail. Then, methods to assess the models performance and their validation are explained.

9.2 MODELLING USING THE MULTIPLE REGRESSION (MR) TECHNIQUE

Having identified potentially important attributes (i.e. independent variables) and satisfaction measures (i.e. dependent variables), choosing the most appropriate technique for analysis and model development was the next important task. As the purpose of the analysis was to develop models to predict levels of satisfaction (i.e. a matter of degree, not an all or none / satisfied or dissatisfied property), the multiple regression (MR) technique was chosen as one of the modelling tools. Multiple regression can include any combination of quantitative (i.e. interval) and qualitative independent variables (i.e. dummy variables) (Hardy, 1993). Moreover, preliminary data examination showed a degree of linear relationship between the dependent and independent variables (see section 9.2.1). The model takes a general form in the following (Lewis-Beck, 1993):

$$Y = a_0 + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n + e$$

where Y is the dependent variable (i.e. satisfaction measure), a_0 is a constant indicating intersect with Y axis, b_n are partial regression coefficients, X_n are independent variables, and e is the error term.

Regression analysis has an established record of use within the social research and especially the construction research communities. In construction, for example, Akinsola (1997) used regression analysis to develop a model for predicting variation contingencies on construction projects; and Edwards (1999) to predict total plant maintenance costs.

9.2.1 Regression Assumptions

In order that meaningful analysis is conducted, several assumptions need to be made when using MR techniques. Here, assumptions of normality, constant variance and linearity should not be violated. Any departure from the regression assumptions can be detected by examining the distribution of the residuals and their relationships to other variables (Everitt and Dunn, 1991; Lewis-Beck, 1993; Norusis, 1995).

9.2.1.1 Normality assumption

This assumption can be checked by examining the histogram of residual and normal probability (P-P) plot (Norusis, *ibid.*). The histogram of an ideal normal distribution should be a symmetric bell-shape, with 95% of the observations falling within two standard deviations, plus or minus, of the mean (Lewis-Beck, *ibid.*, Bryman and Cramer, 1999). An example of the histograms obtained for contractors' assessment of client performance is given in Figure 9.1. Plotting observed cumulative probability against expected cumulative probability, the normal probability (P-P) plot indicates that if the data are a sample from the normal distribution, the points should fall more or less on a straight diagonal line (for example, refer to Figure 9.2). Figures 9.1 and 9.2 confirm that the distribution is normal. Similar results were derived for the other participants as presented in Appendix I.

9.2.1.2 Constant variance

To check whether the variance of the dependent variable is the same for all values of the independent variable, the plot of studentised residuals against predicted values should be examined. Here, studentised residual is preferred to standardised residual because it takes into account the variability of the predicted value which is not constant for all points but depends on the value of the dependent variable. Due to this, the studentised residual makes it easier to see violations of the regression assumptions (Norusis, *ibid.*). The residual should appear to be randomly scattered around a horizontal line through 0 (Lewis-Beck, *ibid.*; Norusis, *ibid.*). If there is a pattern (such as a funnel shape), this means the variance of the dependent variable is not the same for all values of independent variables (Lewis-Beck, *ibid.*; Norusis, *ibid.*). A typical example is shown in Figure 9.3 confirming that the variance of the residual is constant.

9.2.1.3 Linearity

Linearity can be checked by plotting the independent variables against the dependent variable. However, it can also be evaluated by plotting the studentised residuals against the predicted values (Lewis-Beck, *ibid.*; Norusis, *ibid.*) as shown in Figure 9.3. If the relationship between the dependent variable and independent variables is not linear, the plot will form a curve (Lewis-Beck, *ibid.*; Norusis, *ibid.*). The typical example in Figure 9.3 confirms that the relationship between independent and dependent variables is linear.

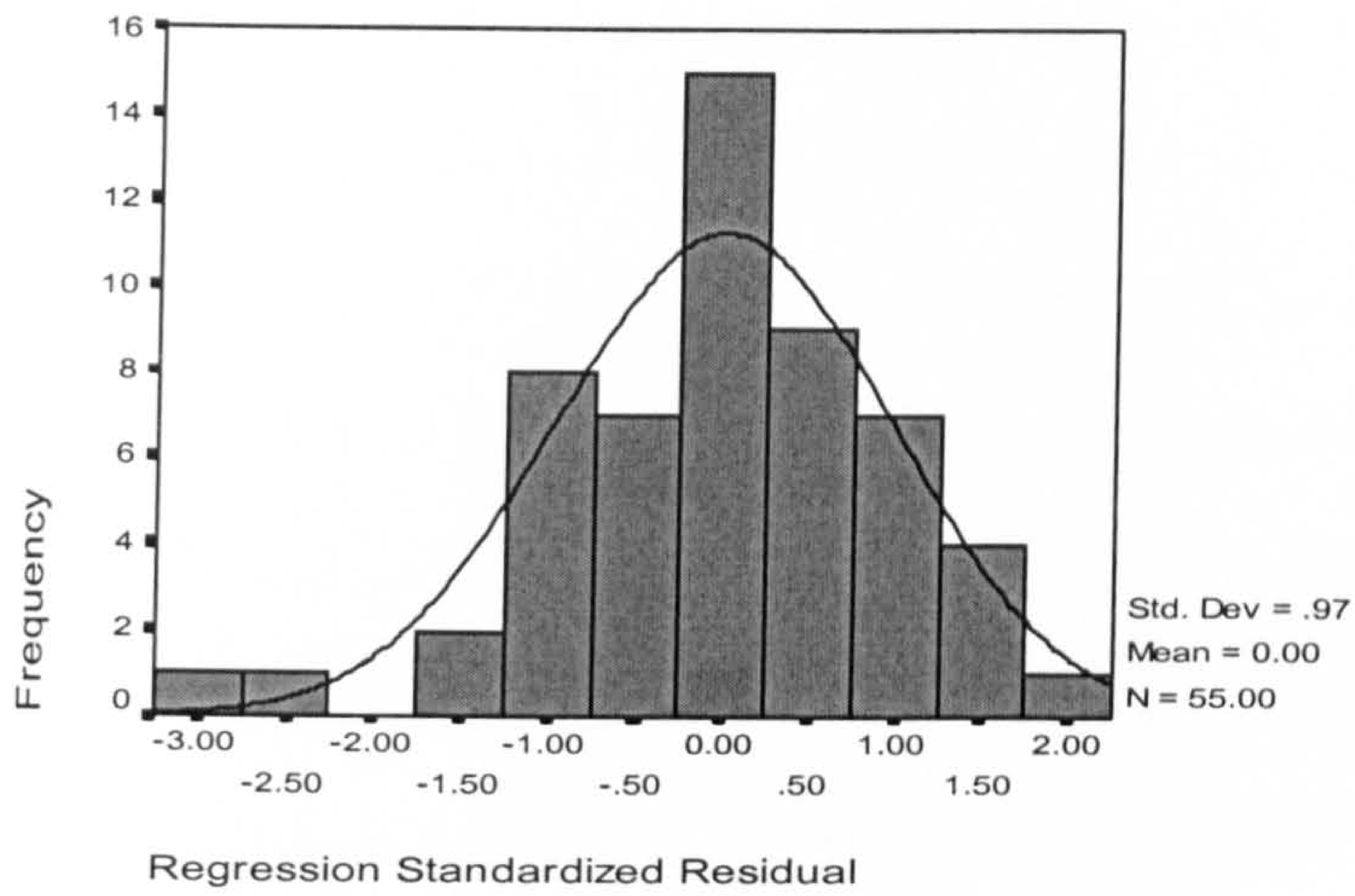


Figure 9.1 Histogram of standardized residuals for *totsat*

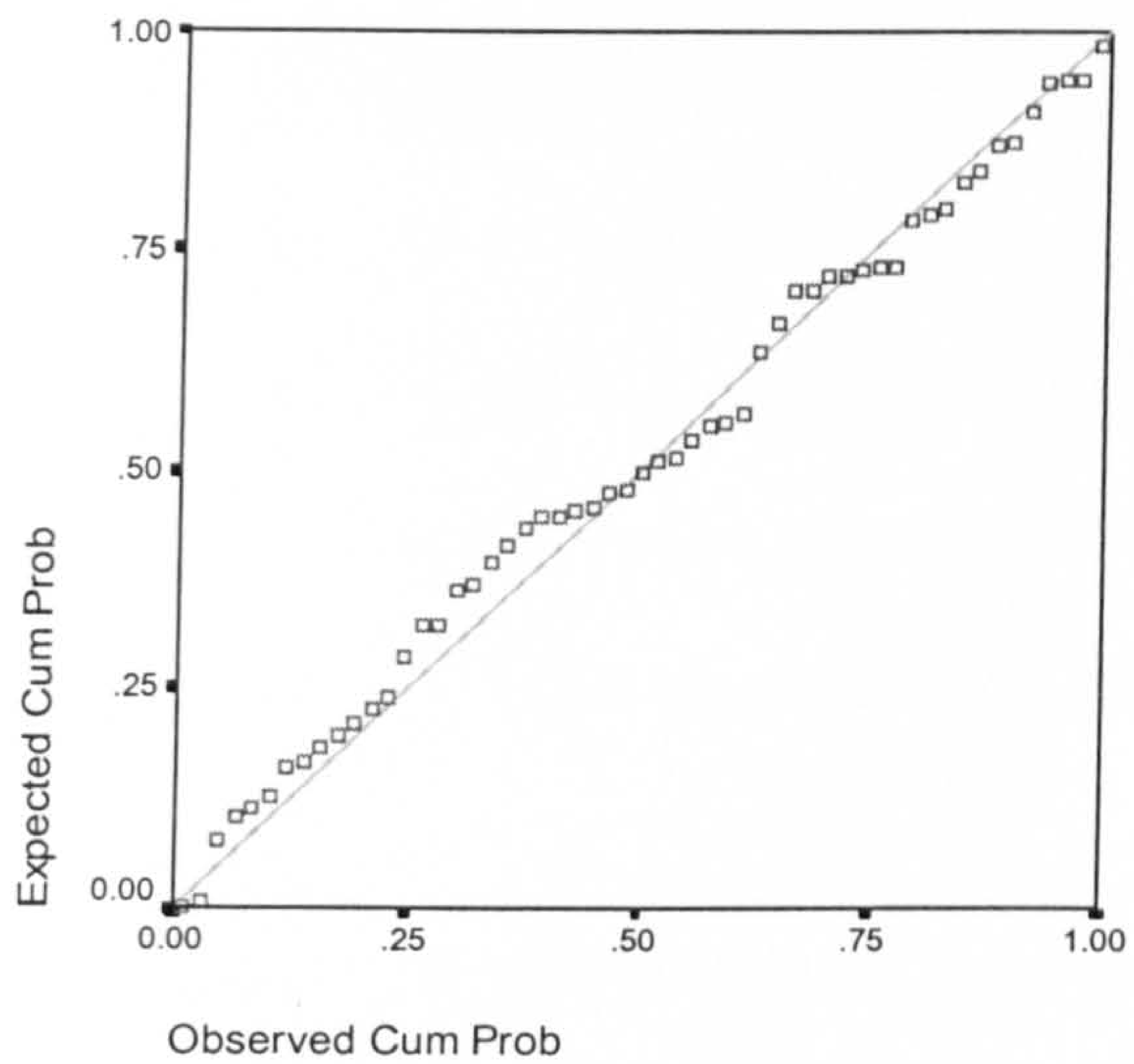


Figure 9.2 Normal probability (P-P) plot for *totsat*

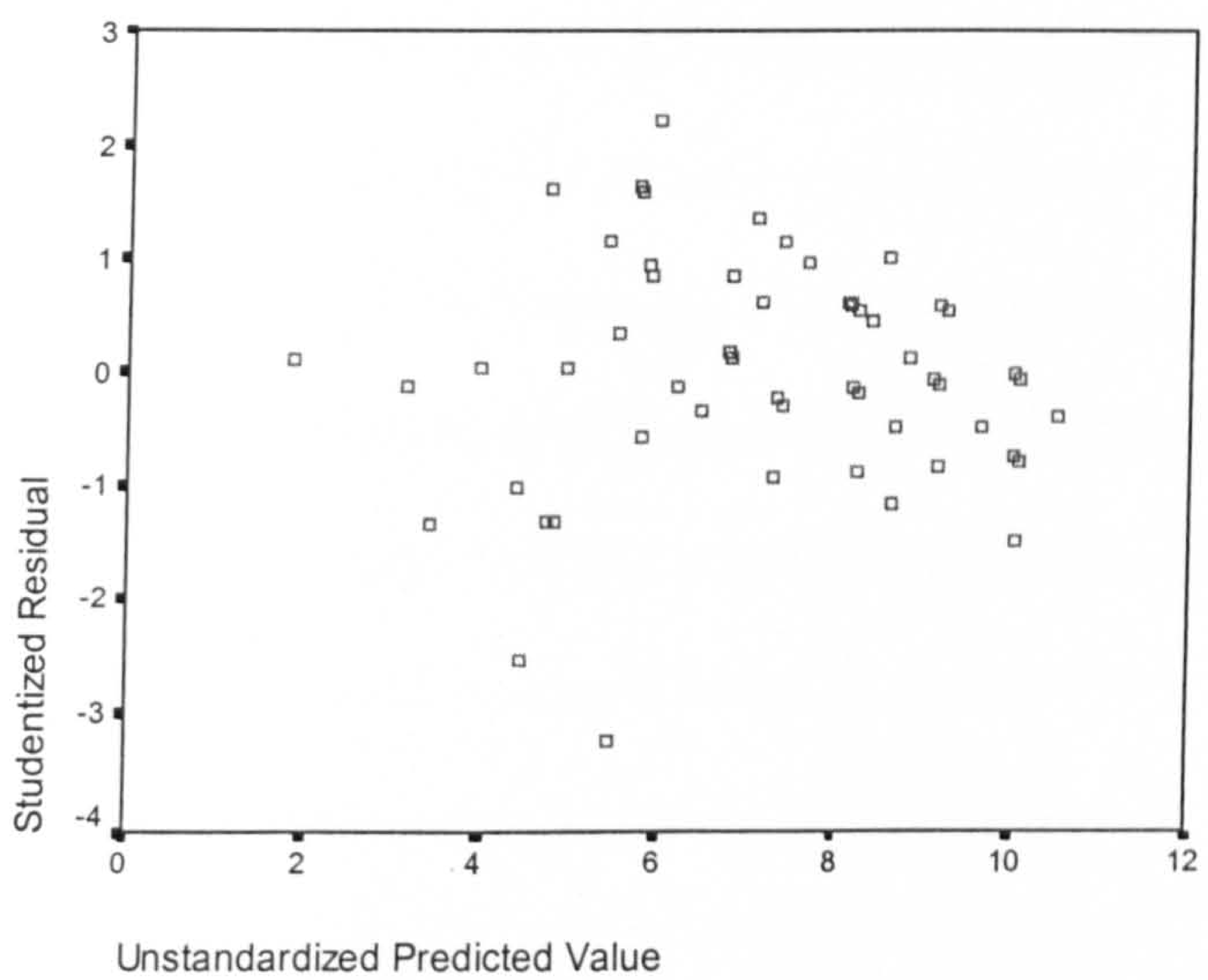


Figure 9.3 Studentized residuals versus predicted values for *totsat*

9.2.2 Utilisation of Stepwise Variable Selection Procedure

Stepwise multiple regression is the most commonly used method for model building (Everitt and Dunn, 1991; Norusis, 1995; Bryman and Cramer, 1999). Draper and Smith (1981) regarded step-wise as one of the best variable selection procedures. For example, this procedure has been used by Hua (1996) to select significant indicators for forecasting residential construction demand. The analysis utilises a stepwise method for inclusion / exclusion of independent variables. The procedure selects the independent variables step by step. At each step, variables already in the equation are evaluated according to the selection criteria for removal, and variables not in the equation are evaluated for entry. This process repeats until no variable in the block is eligible for entry or removal (Norusis, *ibid.*). F-statistics with probability of 5% and 10% were employed for entry and removal criteria. The significant level for entering a variable should be smaller than the significant level for removing a variable, otherwise the analysis will not stop (Norusis, *ibid.*).

Although popular, the stepwise procedure has been claimed to be controversial because it includes independent variables based on statistical criteria and not theoretical ones (Bryman and Cramer, *ibid.*). This means independent variables showing highest correlation with the satisfaction measures will be included, while conversely, independent variables which are less correlated will be excluded from the model. This does not mean that these excluded variables are not important, just that they explain the same thing and are superfluous from an analytical (not theoretical) point of view (Kleinbaum and Kupper, 1978; Kzranowski, 1988 cited in Edwards, 1999).

9.3 MODELLING USING THE ARTIFICIAL NEURAL NETWORK (ANN) TECHNIQUE

The Artificial Neural Network (ANN) technique is a branch of Artificial Intelligence (AI) which attempts to mimic human neurons (i.e. the brain). ANN is an adaptive system that can learn from data presented and capture underlying relationships between input (i.e. independent) and output (i.e. dependent) variables even if they are difficult to find and describe. ANN can cope with noise, imprecision and complexity, which are not uncommon in the real world (Hammerstrom, 1993). Due to this, ANN can learn complex non-linear relationships between dependent and independent variables. This also enables ANN to capture interactions among the independent variables. Hammerstrom (*ibid.*) described this relationship as a higher-order function which means that the effect of changing an independent variable on a dependent variable depends on the values of other independent variables. In linear systems, this change produces a proportional change in the dependent variable and the effect depends only on the input value.

In linear systems such as the multiple regression (MR) technique, the relationships between dependent and independent variables have initially been established (i.e. linear equation), while in non-linear systems such as the ANN technique, these relationships are unknown. Instead, ANN learns the problem and adjusts the weights of its processing elements by continuous presentation of data. Thus, ANN learns the problem by experience.

Having been trained properly, ANN models can generalise to new 'unseen' data. This is one of the most important characteristics of ANN enabling it to be used to solve complex problems. Here, ANN is used as a tool to predict satisfaction levels for reasons explained in the following.

In problems that involve complex non-linear relationships, the ANN technique has been proven to be more accurate than traditional techniques (i.e. such as MR) (Hammerstrom, *ibid.*; Chao and Skibniewski, 1994; Hua, 1996). This is because complex problems can not be explicitly represented in mathematical or statistical terms, or the explicit representation of these problems causes a loss of sensitivity due to over-simplification (Boussabaine, 1996). However, the ANN technique also has several weaknesses. Like decisions made by human experts relying on heuristic judgements, the output of ANN can not easily be explained (Hammerstrom, *ibid.*; Fu, 1994; Boussabaine, *ibid.*). This lends itself to the heuristic nature of ANN's problem solving. The absence of this explanatory capability in an ANN model has traditionally been termed a 'black box' (Hua, *ibid.*). Moreover, the process of model development and training depends largely on experimentation. There are no specific rules to follow for determining the model architecture and learning parameters (Hua, *ibid.*), instead guidance (which is particularly useful at the beginning of modelling) has to be sought from (e.g.) software manuals and literature. This guidance may enable a researcher to develop an optimum model (i.e. that which is simple but representative of the 'real world') and ease the training process. There is also no assurance that the network trained is the best configuration possible (Boussabaine, *ibid.*). All networks suffer from limitations in their ability to learn and recall, and hence are prone to errors (Boussabaine, *ibid.*). The networks are also very much problem dependent.

In construction management, there have been many examples of ANN applications over the last decade or so. This is because ANNs are particularly suitable for analogy-based decision problems prevalent in construction (Moselhi *et al.*, 1991). For example, Chao and Skibniewski (*ibid.*) used ANN to estimate construction operation productivity. Hua (1996) used ANN to predict demand for residential construction in Singapore. Akinsola (1997) utilised ANN to predict variation contingencies in construction projects. Using a similar ANN paradigm, Edwards (1999) predicted total average maintenance costs of hydraulic excavators. Hua (*ibid.*), Akinsola (*ibid.*) and Edwards (*ibid.*) compared ANN prediction and MR prediction and concluded that the ANN technique was generally more accurate. As described earlier, the ANN technique has several characteristics which make it distinct from MR. Given the 'soft' nature of satisfaction and the involvement of subjective judgements, it was anticipated that the data would be appropriate for ANNs, i.e. that it could be noisy, biased, complex and non-linear. Moreover, there being a large number of attributes (i.e. input variables) which had to be considered in parallel (Moselhi *et al.*, *ibid.*) fully justified the use of ANN as a tool for predicting satisfaction levels.

9.3.1 Development of ANN Models

Development of ANN models using language programming requires a comprehensive mathematical knowledge and computer programming skills. However, recent advances in computer software have enabled this technique to be used by 'lay-men' and to become accessible to wider applications. ANN software packages now provide user-friendly tutorials and *Neuralwizards* which guide the user through the key stages of ANN development (Edwards, *ibid.*). In this research, *NeuroSolutions* neural network simulation environment version 3.02 consultants level was used (NeuroDimension, 1999) to develop the ANN models. Here, the *NeuralWizards* is a separate application that aids in the design and construction of a neural network. It presents a series of panels that represent logical steps in the design process (NeuroDimension, 1999). This facility enables ANN models to be developed, tested and validated relatively easily.

In general, the development of ANN models comprises three phases, i.e. design, learning and recall (Moselhi *et al.*, *ibid.*) (refer to Figure 8.4). The design phase involves analysing the problem (i.e. to identify attributes and performance criteria), consideration of design (for example, classification or regression problem), selecting the neural paradigm, and determining neural and learning variables. As mentioned previously, determining the architecture of an ANN model is based mainly on trial and error and guidance suggested in the manuals (NeuroDimension, 1995a; b; 1999) and literature (Boussabaine, *ibid.*; Hua, *ibid.*; Bhokha and Ogunlana, 1999; Khosrowshahi, 1999). The learning phase mainly involves 'training' or presenting the data into the designed network (i.e. running the programme). The design and learning phases are a repetitive process involving changing the network parameters and learning variables to find an optimum model. The recall phase involves testing the trained network or putting the network into use. Each phase will be described in detail in the following sections for one of the models developed, that being the architects' assessment of contractor performance.

9.3.1.1 Design phase

The first step of the design phase involves analysing the problem, that is predicting levels of satisfaction using the performance and satisfaction attributes. A model was developed for each performance assessment case using the overall satisfaction measure. Here, for each model, there is one desired output channel (i.e. dependent variable) and many input channels (i.e. independent variables). The dependent and independent variables used here were the same as those used in the multiple regression models.

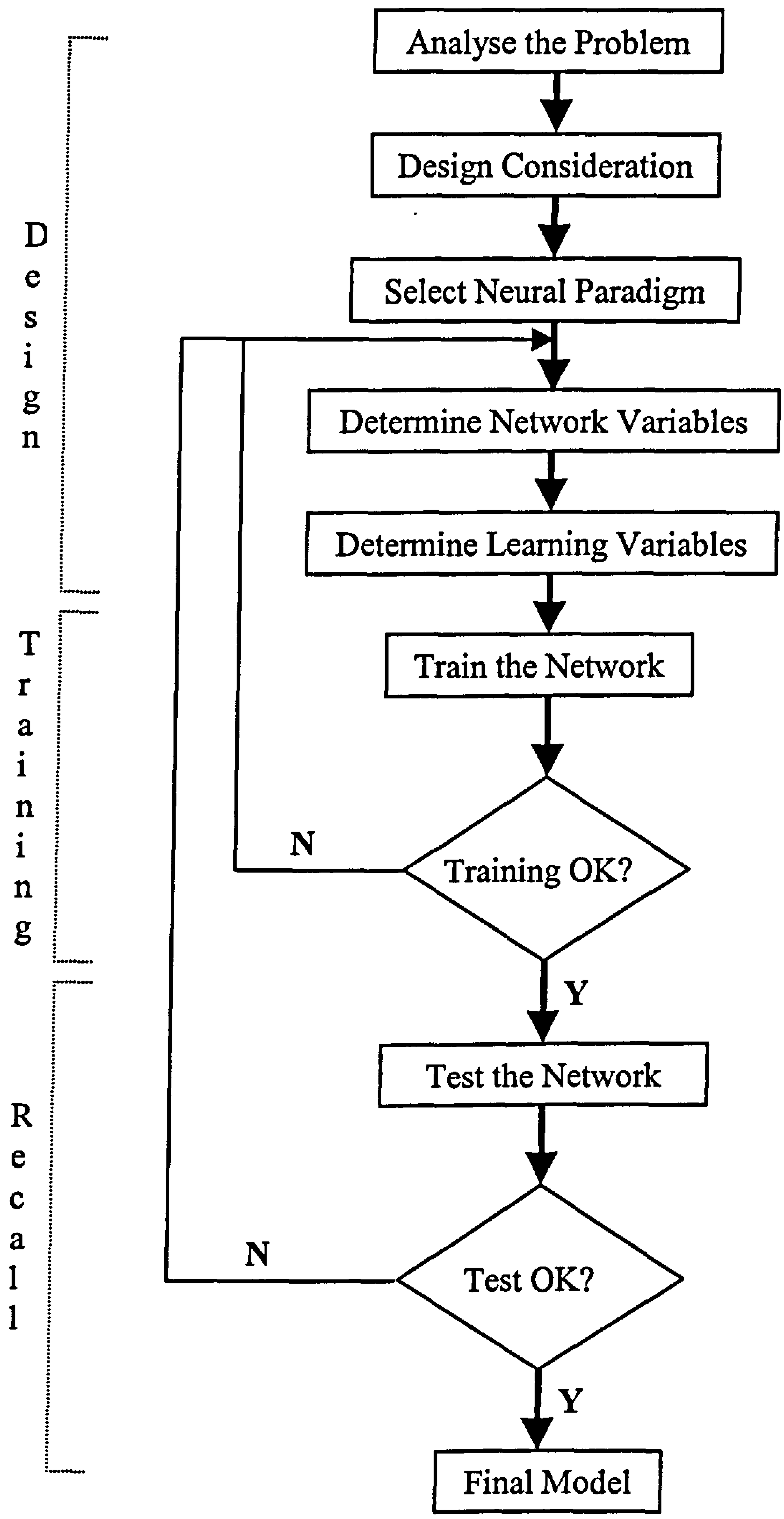


Figure 9.4 Flowchart of ANN model development

The aim being to predict the degree of satisfaction, this could be classified as a regression problem, i.e. relating one continuous dependent variable with several independent variables.

The next step was to select the neural paradigm. The Multilayer Perceptron (MLP) is commonly used for general classification and regression problems, in which, this paradigm has an advantage over other paradigms (NeuroDimension, 1999). MLP has been used by Chua *et al.* (1997a,b), Bhokha and Ogunlana (1999), and Cheung *et al.* (2000) and was also used here. The MLP is often termed 'fully connected feedforward architecture' since this definition describes the method by which data flows through the network structure (refer to Figure 8.5). This paradigm normally contains three layers of processing elements, i.e. input, hidden and output layers. The input layer contains input data, hence the number of processing elements in this layer is equal to the number of variables. The hidden layer(s), where the mathematical calculations of weights are conducted, are invisible to the outside world. The number of hidden layers could be one or more, or even no hidden layer (i.e. linear computation) (NeuroDimension, 1999). Although increasing the number of hidden layers increases the computing power of the network, this also increases complexity and computing time. The output layer represents the computational output of the network, here this is the satisfaction levels. In this research, a single hidden layer MLP was adopted since, for regression problems, a single hidden layer MLP has been claimed to be able to learn any problem if there are sufficient numbers of processing elements (PEs) in that layer (NeuroDimension, 1999). This is also to keep the models as simple as possible since the best / optimum model is the model which is simple but still able to represent the real world (Khosrowshahi, 1999). Moreover, with the same number of exemplars (i.e. case projects), adding hidden layers increases the computing power at the expense of generalisation (NeuroDimension, 1995a).

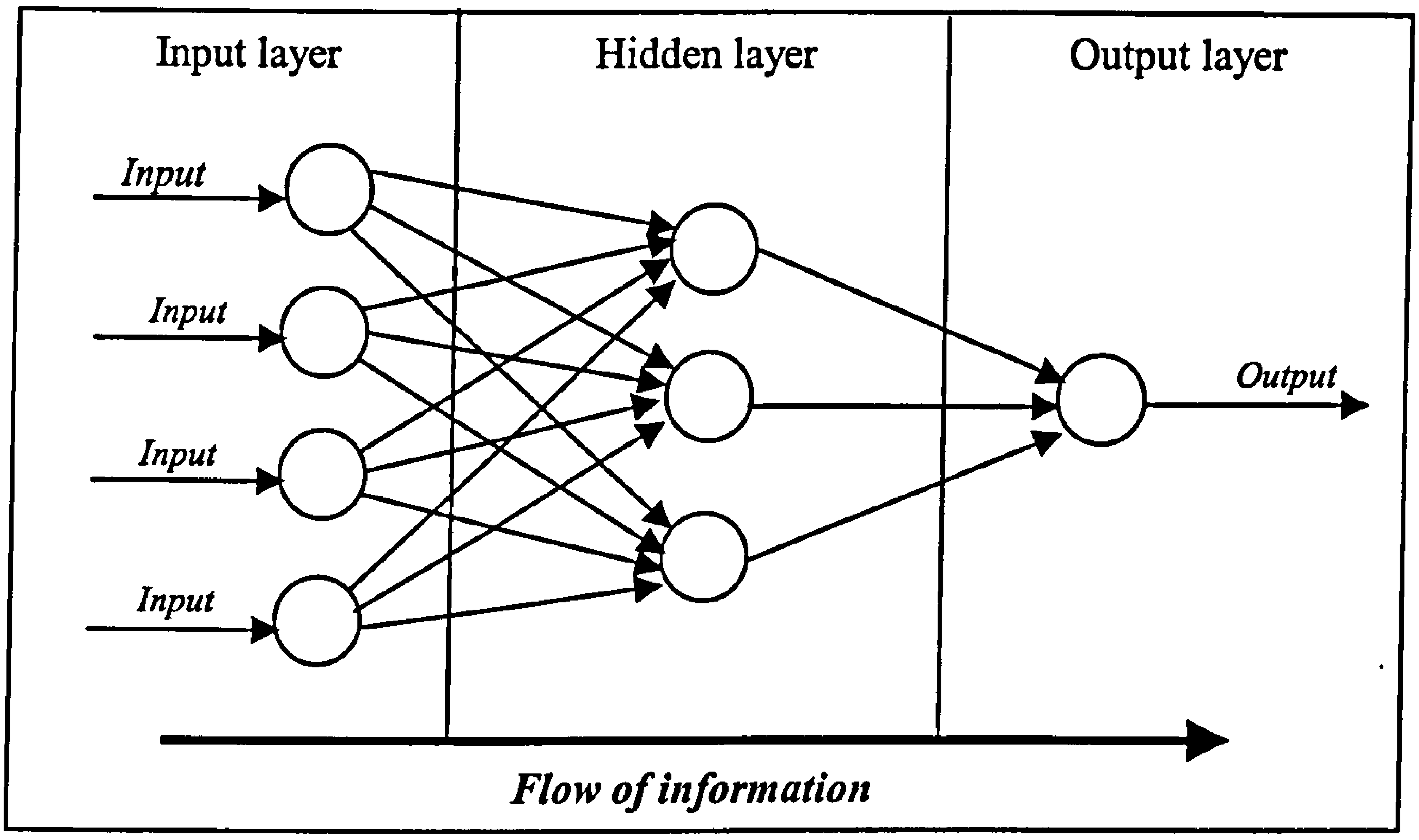


Figure 9.5 Simple multilayer perceptron (MLP) architecture

The learning process maps the data into the network by adjusting the weights of processing elements of the network. This means that, for each iteration, error is calculated and then weights adjusted so that subsequent iteration will produce less error. There are two common forms of learning, i.e. supervised and unsupervised. Here, since the MLP paradigm was used, the supervised learning was appropriate and, hence adopted. For MLP supervised learning, the most popular learning rule is backpropagation or the generalised delta rule which was adopted in this research.

The number of PEs in the hidden layer directly affects the overall computing power of the network. The number of PEs is ideally chosen based on the complexity of the desired input-output mapping of the data. Since complexity is problem-dependent and not exactly known by the researcher, the number of PEs can only be determined experimentally (NeuroDimension, 1999). It is important to note that good generalisation of new data depends on finding the minimal number of PEs that can still learn the problem (NeuroDimension, 1999). Too many PEs causes poor generalisation of the network (NeuroDimension, 1995a; 1999). This is because a network with too many PEs and without much training data (i.e. exemplars) is able to ascertain many patterns, all of which are consistent with the training data, but where most of which are poor approximations of the actual model, i.e. overfitting (Boussabaine *et al.*, 1999). Conversely, a network with too few PEs will not be able to learn the problem because the network does not provide sufficient mapping space for the model (Boussabaine *et al.*, *ibid.*). Normally, the number of PEs should be proportional to the amount of data (NeuroDimension, 1995a).

Non-linearity of ANN models is very much determined by non-linearity of transfer function in their PEs. *TanhAxon* and *SigmoidAxon* are commonly used in the hidden layer(s). *TanhAxon* function ranges between –1 to 1 and *SigmoidAxon* function ranges between 0 to 1. Before input data is processed in the PEs, the data is automatically normalised by the software to match the range of the transfer function of the first hidden layer (NeuroDimension, 1999). For example, if the *TanhAxon* function is used, then input data is normalised in a range between –1 and 1. Since *SigmoidAxon* (which output ranges between 0 to 1) produce zeros, and learning does not occur when the input to transfer function is zero, *TanhAxon* was adopted as transfer function in the PEs of hidden and output layers. Due to this, *TanhAxon* speeds up the training process (NeuroDimension, 1999).

As previously described, learning aims to map data into desired input-output relationships in which errors are gradually reduced by continuous presentation of data. This can be achieved by updating the weight of network's PEs. In the backpropagation algorithm, the learning rule, or gradient search, is used to calculate the weight update. Gradient search looks for universal minima of a non-linear curve. However, this can become stuck in local minima instead of universal minima, in which the learning curve (i.e. graphical illustration of error (y-axis) by number of iteration (x-axis)) fails to converge (NeuroDimension, 1995a, p. 39). This constitutes one possible reason for unsuccessful training.

To control the rate of learning during the training stage, the *Momentum* learning rule was utilised. Although it is not potentially as fast as *QuickProp* or *DeltaBarDelta*, *Momentum* learning is more stable (NeuroDimension, 1999). Two learning parameters have to be determined, that is *momentum* term and *step size*. Momentum term is influenced by the size of previous weight changes. Momentum should normally be set between 0.1 and 0.9 (NeuroDimension, 1995a). If the learning curve oscillates, this means that momentum is set too high and should be subsequently reduced. Step size normally ranges between 0 and 1. To speed up the training time, it is recommended to use smaller step sizes for layer(s) near the output than layer(s) near the input. This is because the gradient becomes attenuated by each layer as it is backpropagated from the output to the input, and this can cause layers near the input to learn very slowly (NeuroDimension, 1999). The larger the step size the faster the minimum will be reached. However, if the step size is too large, then the algorithm will diverge and the error will increase instead of decrease. If the step size is too small then it will take too long to reach the minimum, which also increases the probability of getting caught in local minima (NeuroDimension, 1995a). The appropriate step size can only be determined experimentally since the 'best' step size is very much dependent on the error surface for which data is rarely available (Edwards, 1999). Therefore, to develop an optimum ANN model, a repetitive process of design and training is needed.

Training can be terminated by setting either a maximum number of iterations (i.e. epochs) or a maximum permissible error. Here, the latter was adopted, that is training stops when mean square error (MSE) reaches the predetermined threshold. This prevents the network from overtraining, and thus it is particularly desirable where cross-validation is not being used (NeuroDimension, 1999). Cross-validation is a process whereby part of the training data is set aside for the purpose of monitoring the training process, to avoid overtraining. However, if the training data-set is relatively small (such as in this research), it may not be possible to split the data set (NeuroDimension, 1999). Therefore, a termination criterion, i.e. a predefined MSE, was used. It is recommended that networks should be trained until the MSE is less than half of the performance error (NeuroDimension, 1995a). Here, the MSE was initially set at 0.005 and adjusted based on experimentation to a level of 0.01 when needed.

9.3.1.2 Training phase

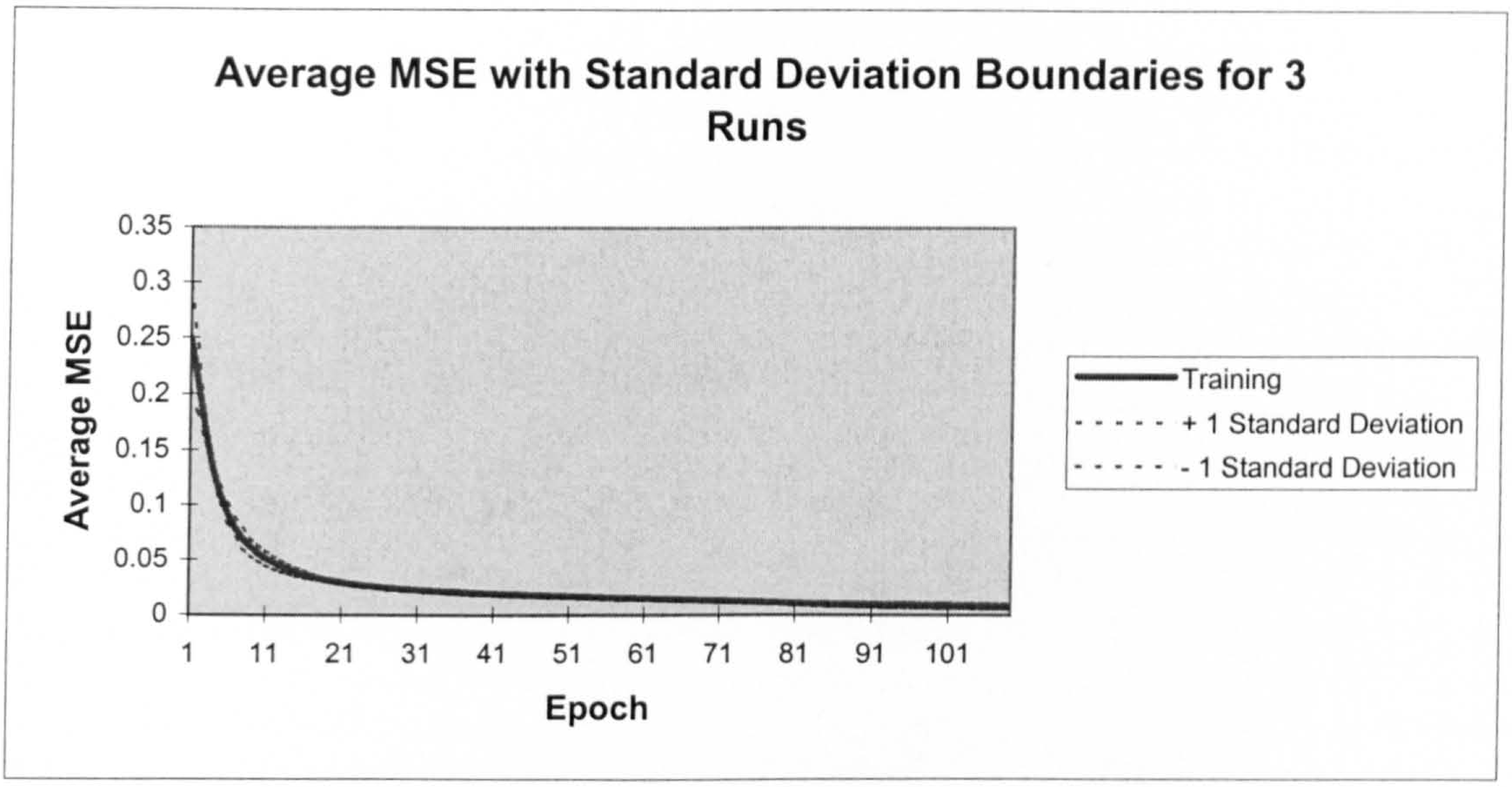
Having been constructed, the network was now ready to be 'trained.' Training involves continuous (i.e. repetitive) presentation of data to the network in which the network is able to learn the problem by adjusting its weights so that the error produced by the output layer is gradually reduced. Here, the learning curve should be observed carefully as a basis to judge whether any alteration to the network parameters and/or learning variables is necessary to produce the 'best' model. For example, if the curve converges too rapidly, there may be too many PEs in the hidden layer or the step size may be too large. If the learning seems too slow, there may be too few PEs or too small a step size. Then, subsequent actions can be taken to revise the network's appropriate parameters and re-train the revised network. Effective training to produce optimum models (for example, observation of learning curve and/or number of epochs to reach MSE) can only be achieved through experientation, i.e. designing, training and testing the network. This refers to Figure 8.4.

Variability in the performance of the trained network may occur due to differences in the initial condition (such as pre-randomised initial weight). Therefore, a network should be trained several times. Here, the network was trained three times and then the 'best' trained network was chosen. The 'best' trained network is that which reaches the mean square error's threshold fastest, i.e. trained with the least epochs. Figure 8.6 reports this training demonstrating how the best network was selected.

9.3.1.3 Recall phase

The recall phase puts the trained network into use. Here, the network was tested against data retained for validation purposes. The predictive performance of the ANN model was assessed by comparing predicted and actual levels of satisfaction using two model performance measures, i.e. mean absolute deviation and mean absolute percentage error. Additionally, Pearson's correlation and chi-square tests were conducted to confirm the accuracy (i.e. validity) and consistency (i.e. reliability) of the predictive performance of the model. Full explanation of this method is described in section 8.4.

Generalisation or the capability of the network to generalise to new data and hence produce valid results is dependent on how design and training are conducted. There is no



All Runs	*Training Minimum*	*Training Standard Deviation*
Average of Minimum MSEs	0.0075	0.0024
Average of Final MSEs	0.0075	0.0024

Best Network	*Training*
Run #	3.0000
Epoch #	109.0000
Minimum MSE	0.0048
Final MSE	0.0048

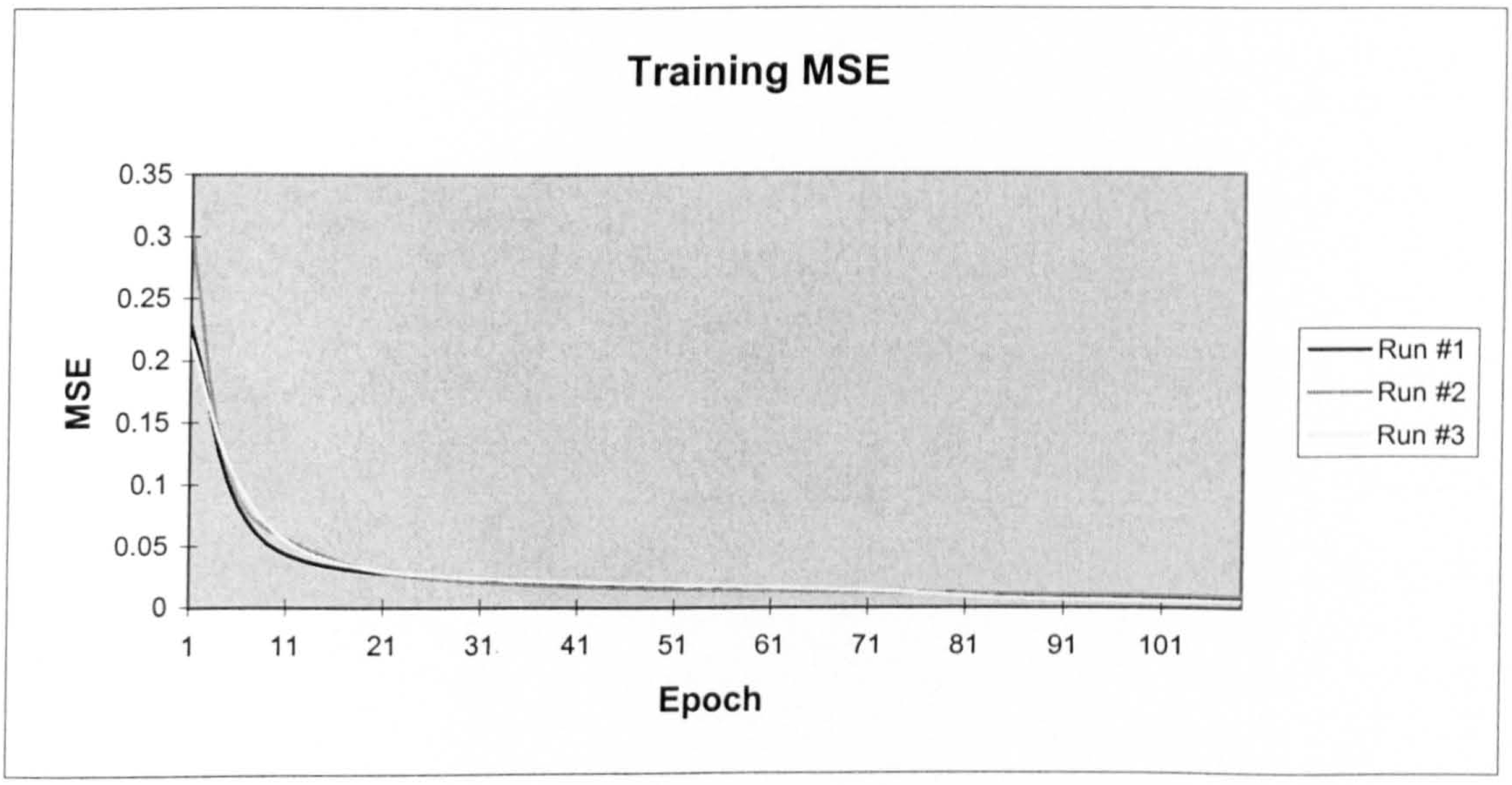


Figure 9.6 Training report for selecting the best network

such measure or indicator to gauge generalisation. Instead, this can only be observed from the results, that is testing the network against new 'unseen' independent data. If a model is found to be suspect since it does not produce outputs as expected, i.e. not within an acceptable range of deviation, there are at least two possible reasons. The first reason is because training and testing data-sets may not be from the same population and therefore testing results in large deviations (i.e. the model is not valid). However, if training and testing data are randomly separated, and therefore assumed to come from the same population, then the second reason is likely to be the case. The second reason is due to, for instance, overtraining or too many PEs. To investigate this, the network parameters and learning variables should be altered and the network retrained. Then, the trained network should be retested. This process in the ANN model development is shown in Figure 9.4.

9.3.1.4 Identifying important independent variables using sensitivity analysis

To find an optimum model, a two-stage model development process was adopted. Firstly, to identify sensitive (i.e. important) independent variables, sensitivity analysis was applied. Here, sensitivity analysis was used to prune redundant or superfluous variables which may hamper the development of the 'best' model. The *NeuroSolution* package provides a useful facility for this purpose, that is 'sensitivity about the mean.' This sensitivity analysis was run by varying the input between the mean ± one standard deviation while keeping all other inputs constant at their respective means. Then the network output was computed for 50 steps above and below the mean. This process was repeated for each input variable. A report, listing the sensitivity factor for all input variables, was made.

After the first stage, insensitive variables were pruned, leaving sensitive variables for inclusion in the second stage. For a particular network, any variables with sensitivity factor less than 0.1 was excluded from further model development. The second stage of model development followed a similar process to that shown in Figure 9.4. This yielded a simpler model to those developed from the previous stage. This final model could then be used to predict satisfaction levels.

An ANN model has traditionally been termed a 'black box' due to the absence of explanatory capability (Hua, 1996). Moreover, Fu (1994) claimed that a major weakness of ANNs is that the knowledge learned by a network is difficult to interpret. Although using sensitivity analysis, which allowed important input variables to be identified, this analysis could only partially 'explain' the relationships between dependent and independent variables. This is partly because of the non-linear relationship between dependent and independent variables, and partly due to the interactions among the independent variables.

A *sensitivity factor* for each variable was produced. For example, Table 9.1 shows all variables included (first column) and their *sensitivity factors* (SFs) (second column). The sensitivity (later labelled as the *Total Sensitivity Factor*/TSF) of binary variables, which have more than two categories, are average SFs of their categories. This is because binary variables are mutually exclusive which means that if a particular case is classified into one category and assigned as 1 (one), then the other categories are assigned as 0 (zero). Calculations of binary variables' TSFs are given in Table 9.2. Note, their average TSFs (Table 9.2, last row) were then incorporated with the other non-binary variables in Table 9.3. *Total sensitivity factors* are functionally identical as beta weights (β) in multiple regression analysis. These variables could then be ranked according to their TSFs in descending order (Table 9.3, third column). Here, the more sensitive the variable the more important that variable is.

Table 9.1 Independent variables in the second stage ANN model of architects' assessment of contractor performance

Variable	Sensitivity Factor (SF)
COSELCO1	1.8059
PRBUDOV	1.5046
PRTPR2	1.4204
COSELCO0	1.3826
PRTBD1	1.3591
PRROU2	1.3378
COSELCO2	1.2313
PRTBD0	1.1849
PRTBD3	0.7068
PRDUROV	0.6543
PRTBD2	0.6085
RSSATCO	0.5491
COPAYCO1	0.4739
PRROU1	0.4391
COPAYCO2	0.3699
COATTDI	0.3071
PRTPR1	0.2688
PRTBD4	0.2561
PRROU0	0.2526
COATTFI	0.1807
COPAYCO0	0.1692
COPERAR	0.0813
COATTTY	0.0671
PRVARSE	0.0299

Table 9.2 Calculation of total sensitivity factors for binary dummy variables identified from the architects' assessment of contractor performance

COSELCO	SF	COPAYCO	SF	PRROU	SF	PRTBD	SF	PRTPR	SF
COSELCO0	1.3826	COPAYCO0	0.1692	PRROU0	0.2526	PRTBD0	1.1849	PRTPR1	0.2688
COSELCO1	1.8059	COPAYCO1	0.4739	PRROU1	0.4391	PRTBD1	1.3591	PRTPR2	1.4204
COSELCO2	1.2313	COPAYCO2	0.3699	PRROU2	1.3378	PRTBD2	0.6085		
						PRTBD3	0.7068		
						PRTBD4	0.2561		
Average	1.4733		0.3376		0.6765		0.8231		0.8446

Table 9.3 Total sensitivity factors (TSFs) for independent variables identified from the architects' assessment of contractor performance

Attributes	Total sensitivity factor	Ranking
PRBUDOV	1.5046	1
COSELCO	1.4733	2
PRTPR	0.8446	3
PRTBD	0.8231	4
PRROU	0.6765	5
PRDUROV	0.6543	6
RSSATCO	0.5491	7
COPAYCO	0.3376	8
COATTDI	0.3071	9
COATTFI	0.1807	10
COPERAR	0.0813	11
COATTTY	0.0671	12
PRVARSE	0.0299	13

9.4 PERFORMANCE AND VALIDATION OF THE MODELS

The predictive performance of the models was assessed by examining the residual (i.e. the difference between the actual and the models' predicted satisfaction levels). These were measured using two prediction performance measures, i.e. mean absolute deviation (MAD) and mean absolute percentage error (MAPE) (Kvanli *et al.*, 1996). Mean absolute deviation (MAD) can be calculated from:

$$\mathrm{MAD} = \frac{\sum_{i=1}^{n} \mathrm{AD}_i}{n}$$

when

$$\mathrm{AD}_i = |x_i - p_i|$$

where: AD_i is the absolute deviation of the satisfaction level for case project i; x_i is the actual level of satisfaction for case project i; p_i is the predicted level of satisfaction for case project i; and n is the number of case projects (respondents). Mean absolute percentage error (MAPE) can be calculated from:

$$\text{MAPE} = \frac{\sum_{i=1}^{n} \text{APE}_i}{n}$$

when

$$\text{APE}_i = \left| \frac{x_i - p_i}{x_i} \right| \times 100\%$$

where: APE_i is the absolute percentage error of case project i. These formulae conclude that a model yields predicted values with an average deviation of ± MAD, which is MAPE % from actual values. Typically, MAD results were closely linked to MAPE results (i.e. better MAD derives better MAPE). The performance of the model could be arbitrarily classified based on MAD and MAPE as shown in Table 9.4. For data of this nature, MAD of 1.5 to 2.0 and MAPE of 30 to 35% are considered acceptable. MAD of less than 0.5 and MAPE of less than 10% indicate very good predictive performance.

Table 9.4 Classification of model performance based on MAD and MAPE

MAD	MAPE	Model Performance
< 0.5	< 10%	Very good
0.5 – 1.0	10% - 20%	Good
1.0 – 1.5	20% - 30%	Quite good
1.5 – 2.0	30% - 35%	Acceptable

To confirm the robustness (in term of consistency and accuracy) of the models in predicting satisfaction levels, the performance of the models was tested using chi-square (χ^2) analysis and Pearson's correlation coefficient (Edwards, 1999). The null hypothesis (H_0) for χ^2 test is that there is no significant difference between the actual and predicted levels of satisfaction. A two-tailed test was used because the hypothesis aims to determine whether there is a difference at all and not simply an improvement (as with a one-tailed test) (Edwards and Holt, 2000). This implies that the model has consistent predictive performance at the 5% level of significance (Edwards and Holt, *ibid.*). The H_0 for Pearson's correlation test is that there is no correlation between predicted and actual satisfaction levels. Here, a one-tailed test was used. This was to confirm that the satisfaction levels can be predicted with a significant level of accuracy, using the given independent variables in the model (Edwards and Holt, *ibid.*). Both tests were to confirm whether the models were valid and robust.

9.5 SUMMARY

This chapter has described the two main techniques adopted to develop models of satisfaction. Here, multiple regression, representing a traditional linear technique, and artificial neural network, representing a relatively new non-linear artificial intelligence technique, to relate independent variables and dependent variables were used. The methods implemented for both techniques have been described in detail. Tests conducted to demonstrate the performance and validation of the models have been explained. Subsequent chapters will describe the results of modelling satisfaction based on the assessment of client, architect and contractor performance respectively.

Chapter 10

Modelling Satisfaction Levels Based on Client Performance

10.1 INTRODUCTION

This chapter discusses the assessment of client performance by architects and contractors respectively. For each assessment, multiple regression (MR) and artificial neural network (ANN) models are presented, described, and finally compared. A more detailed discursive of the main findings reported is presented in Chapter 13. A list of independent variables used to develop the models is presented in Table 10.1.

10.2 ARCHITECTS' ASSESSMENT

This section presents the architects' assessment of client performance. Firstly, the MR and ANN models are presented and discussed, including an assessment of their performance and validation. Then, the ANN and MR models are compared.

10.2.1 Multiple Regression Results

The analysis and modelling focused on the overall satisfaction measure (*totsat*). Here, fifty-four case projects (i.e. respondents) were used. The model was investigated for possible violation of the regression assumptions, i.e. normal distribution of residual, equality of variance, and linearity (refer to Appendix I1). The results confirmed that the required assumptions for MR had been met. Results of analysing the multicollinearity problems (refer to section 8.3.1) are presented in Appendix G1. Four combined variables were obtained, namely RSCL12, CLATPPQU, CLATPMQE and CLATTYSI. RSCL12, a respondent combined attribute, consisted of RSCLI1 and RSCLI2, and was interpreted as 'a perception that clients do not know what they want and constantly change their mind'.

Table 10.1 List of independent variables used to develop the satisfaction models of architects and contractors derived from client performance

Variable Name	Code	Questionnaire Item	Measure
SATISFACTION ATTRIBUTES			
ASSESSOR			
involved in similar projects within 5 years	RS5YR	R04	No.
satisfaction on client performance	RSSATCL	R06	likert 0-10
perception on client: client's wants	RSCLI1	R09	likert 0-10
perception on client: changing mind	RSCLI2	R10	likert 0-10
perception on client: minimise cost	RSCLI6	R14	likert 0-10
perception on client: advisors' influence	RSCLI7	R15	likert 0-10
COMPANY ASSESSOR			
number of employees	AR/COEMP	F03	No.
PERFORMANCE ATTRIBUTES			
PROJECT			
type of project	PRTPR (1,2)	P01	nominal
type of building	PRTBD (1,2,3,4)	P02	nominal
procurement route	PRROU (1,2,3)	P06	nominal
planned duration	PRDURPL	P09	time (months)
overrun	PRDUROV	P10	Yes/No
overrun duration	PRDURTI	P11	time (months)
tender sum	PRBUDTE	P12	Sterling (M)
overbudget	PRBUDOV	P13	Yes/No
overbudget cost	PRBUDMO	P14	Sterling (M)
severity of variations	PRVARSE	P15	likert 0-10
design complexity	PRCOMDE	P21	likert 0-10
design completed before work on site	PRDESCO	P23	percentage
constraint by government regulations	PRCONGO	P27	likert 0-10
remoteness from client office	PRLOCCL	P29	likert 0-10
CLIENT			
nature of client business	CLNAT (1,2,3,4)	C01	nominal
no. previous project worked with client	CLWKDBF	C05	No.
no. similar project by client within 5 years	CLSIM5YR	C06	No.
department capacity	CLDEPCA	C08	likert 0-10
department work load	CLDEPWL	C09	likert 0-10
client's organisation structure	CLORGST	C10	likert 0-10
client's communication channel	CLCOMCH	C11	likert 0-10
contractor evaluation prior contract award	CLEVAAR/CO	C12	likert 0-10
client attributes: financial	CLATTFI	C14	likert 0-10
client attributes: type	CLATTTY	C15	likert 0-10
client attributes: size	CLATTSI	C16	likert 0-10
client attributes: past performance	CLATTPP	C18	likert 0-10
client attributes: time reputation	CLATTSC	C19	likert 0-10
client attributes: cost reputation	CLATTBU	C20	likert 0-10
client attributes: quality reputation	CLATTQU	C21	likert 0-10
client attributes: litigation	CLATTLI	C22	likert 0-10
client attributes: project management	CLATTPM	C23	likert 0-10
client attributes: project monitoring	CLATTAU	C24	likert 0-10
client attributes: quality assurance	CLATTQA	C25	likert 0-10
client attributes: representative	CLATTQE	C26	likert 0-10
contractor attributes: working relationship	CLATTWR	C27	likert 0-10

CLATPPQU comprised CLATTPP, CLATTBU, CLATTSC and CLATTQU, and was interpreted as 'past performance of client in general and in terms of cost, time and quality'. CLATPMQE included CLATTPM, CLATTAU, CLATTQA and CLATTQE, and was interpreted as 'the capability of the client's representative'. CLATTYSI covered CLATTTY and CLATTSI, and was interpreted as 'client experience in type and size of project'.

Table 10.2 presents the parameters of the model. The model could be mathematically expressed in the following equation:

Overall satisfaction = 5.008 + 0.472 (the overall satisfaction level arising from client performance in general)
– 2.056 (type of project, specifically extension to existing premises)
+ 0.312 (the capability of the client's representative)
– 0.07829 (planned project duration)
– 0.222 (severity of variations)

The coefficient of determination (R^2) was 0.658 indicating that about 66% of the variation in the overall satisfaction (*totsat*) was explained by these variables. Analysis of variance revealed a significant relationship between the dependent variable and at least one of the independent variables ($F = 18.439, p < 0.0005$). To test the relevancy of each independent variable, a t-test was applied and revealed that each of the independent variables was a relevant predictor of *totsat* given the presence of the other variables in the model.

Table 10.2 Parameters of MR analysis based on architects' assessment of client performance

Multiple R	0.811
R^2	0.658
Adjusted R^2	0.622
Standard error	1.150

Analysis of Variance

	Sum of Squares	D.F.	Mean Square	F	Sig. F
Regression	121.976	5	24.395	18.439	0.000
Residual	63.506	48	1.323		
Total	185.481	53			

Variables in the Equation

Variable	B	Std. Error	β	t	Sig. t	Tolerance	VIF
(Constant)	5.008	0.766		6.536	0.000		
Satisfaction arising from client performance in general	0.472	0.102	0.436	4.613	0.000	0.798	1.253
Type of project, specifically extension to existing premises	-2.056	0.467	-0.373	-4.399	0.000	0.994	1.006
Severity of variations	-0.222	0.063	-0.298	-3.521	0.001	0.993	1.007
Planned project duration	-0.07829	0.021	-0.316	-3.643	0.001	0.950	1.053
The capability of the client's representative	0.312	0.094	0.320	3.318	0.002	0.769	1.300

The model showed good performance (i.e. prediction power) with MAD = 0.85 and MAPE = 13.85% (refer to Table J1.1 in Appendix J), i.e. the model yielded predicted values with an average deviation of ±0.85, which were 13.85% from actual values. The tabulated critical value of χ^2 (Tab χ^2) at the 0.05 level of significance (70.993) was greater than the calculated χ^2 (Calc χ^2) (9.243) confirming that the predicted *totsats* were not significantly different from the actual *totsats*. Pearson's correlation coefficient between the predicted and the actual *totsats* was found to be significant (r = 0.811, p = 0.000) confirming that *totsats* can be predicted with significant accuracy given the independent variables in the model.

To assess the validity of the model, similar measures and tests were applied to the hold-back data (i.e. that which had not been used to develop the model), with results presented in Table J1.2 in Appendix J. Results indicated that the model had an acceptable predictive performance (MAD = 1.37 and MAPE = 23.67%), the predicted *totsats* were not significantly different from the actual *totsats* (Calc $\chi^2 = 7.580 <$ Tab $\chi^2 = 23.685$) and that the *totsats* could be predicted with significant accuracy (r = 0.524, p = 0.023). In sum, these suggest that the model is valid and robust.

10.2.1.1 Discussions

A multiple regression model has been developed to predict and describe architects' satisfaction levels based on client performance. The model is discussed in the following paragraphs.

The model included five significant independent variables, namely, in descending order of importance, (i) the satisfaction arising from client performance in general, (ii) type of project, specifically extension to existing premises, (iii) the capability of the client's representative, (iv) planned project duration and (v) the severity of variations. The satisfaction arising from client performance in general was the most important variable suggesting that subjectivity is prevalent in the architects' performance assessment. That is, architects who perceive client performance in general to be for example poor, are less likely to be satisfied with their performance, and vice versa. This further confirms the validity of the performance assessment model described earlier in Chapter 1 (section 1.3). It is interesting to note that, for projects involving extensions to existing premises, architects were found to be less satisfied with client performance. One possible reason is the uncertainty inherent within such projects, which may introduce more variations than on new-build projects. It is not really surprising that the performance of clients in the construction process is very much influenced by the capability of their representative. That is, the careful selection of the client's representative is crucial to client performance and, ultimately, project performance. It is interesting to note that larger projects were found to lower satisfaction levels. Projects involving longer construction times are more likely to be large prestigious contracts, demanding higher levels of client performance. It is of no real surprise to find that satisfaction levels are negatively influenced by the severity of variations because this problem often causes poor project performance.

The independent variables identified by the model comprised a combination of one satisfaction attribute, three project attributes and one client performance attribute. This indicates that the satisfaction of architects is not solely dependent on client performance but also on project attributes and on architects' general perception of clients. This concurs with the conceptual performance assessment model which hypothesised that satisfaction levels are dependent on performance and satisfaction attributes. However, the model developed has to be interpreted with caution since it explained about 66 percent of the variation in satisfaction levels. The remaining 34 percent of the variation was unexplained by the model. This indicates that there might be cases where the model is inaccurate. Generally, the model suggests that these five variables are useful in predicting levels of architect satisfaction derived from client performance.

10.2.2 Artificial Neural Network Results

As in the multiple regression analysis, an ANN model was developed to predict levels of architect satisfaction based on client performance. Table 10.3 shows the network typologies for the first and second stage models. Based on the results of the first stage model, insensitive independent variables were pruned. The remaining variables were used to develop the second stage model. The second stage model was then used to predict satisfaction levels. Table 10.4 depicts the independent variables used to predict architect satisfaction levels in descending order of importance based on the results of the sensitivity analysis (for calculations, refer to Appendix K1).

The performance of the model was very good with MAD of 0.36 and MAPE of 5.65% which indicated that the model yielded predicted values with an average deviation of ±0.36, which were 5.65% from actual values (refer to Table L1.1 in Appendix L). Furthermore, correlation and chi-square tests confirmed the accuracy and consistency of the model. Pearson's correlation coefficient ($r = 0.967$) and calculated chi-square (1.887) indicated that the model had been successfully trained and was able to learn the problem. Subsequent validation tests showed that the model had MAD of 1.16 and MAPE of 19.53% (refer to Table L1.2 in Appendix L) indicating quite good predictive performance. Correlation ($r = 0.796$; $p = 0.000$) and chi-square (calculated chi-square = 3.853 <

tabulated chi-square = 23.685) tests confirmed the accuracy and consistency of the model against independent data (i.e. the model was valid and robust).

Table 10.3 Network typology for first and second stage models of architects' assessment of client performance

Network and learning parameter	First stage model	Second stage model
Type of input variables	Continuous and binary	
Type of output variables	Continuous	
Number of hidden layer	1	1
No. of PEs in input layer	53	16
No. of PEs in hidden layer	3	6
No. of PEs in output layer	1	1
Transfer function	TanhAxon	
Network connectivity	Fully connected	
Learning law	Backpropagation	
Learning algorithm	Momentum	
Step size	0.5, 0.1	0.5, 0.1
Momentum	0.7	0.6
Minimum Mean Square Error	0.0048	0.0098
No. of training epochs	185	221

Table 10.4 Total sensitivity factors (TSFs) for sensitive independent variables identified from the architects' assessment of client performance

Attributes	Total Sensitivity factor	Ranking
Type of project	0.9073	1
Procurement route	0.6834	2
Nature of client business	0.6346	3
Type of building	0.5441	4
Satisfaction arising from client performance in general	0.3871	5
Project overbudget	0.3465	6
Project management experience	0.1756	7
Project overrun	0.1610	8
Qualification and experience of the client's representative	0.0784	9

10.2.2.1 Discussions

Of the 53 independent variables, 16 (including some dummy variables) were identified as useful predictors in the architect satisfaction model. These were aggregated to arrive at 9 variables. These variables were ranked according to their importance (i.e. TSFs) (refer to Table 10.4).

Type of project was the most sensitive variable. In the context of this research, this variable is considered beyond the influence of the project coalition participants and therefore can not be used to maximise levels of satisfaction. The selection of an appropriate procurement route is also crucial to architects' satisfaction. Here, long-term, relationship based procurement routes, such as partnering and strategic alliances may have advantages over traditional competitive tendering routes. It is quite interesting to note that the nature of clients' business is one of the sensitive variables indicating that the characteristics of the client may influence architects' levels of satisfaction. The variable, type of building is considered similar to the variable type of project and is largely outside the influence of the project coalition participants.

The satisfaction arising from the client performance in general was also a sensitive variable. This supports the MR model (refer to section 10.2.1.1, second paragraph) and indicates that subjectivity is prevalent in the architects' performance assessment. That is, architects who perceive client performance in general to be for example poor, are less likely to be satisfied with their performance, and vice versa. This also confirms the validity of the performance assessment model (refer to section 1.3).

The model indicates that architects were found to be less satisfied when working on projects overbudget and behind programme which may be linked to the need to commit additional resources. It is interesting to note that project management experience, and qualification and experience of the client's representative were sensitive variables. These variables suggest that the past performance and experience of the client influence architects' satisfaction levels. Moreover, the client's representative should also be selected carefully.

10.2.3 Comparative Analysis

Table 10.5 compares the performance of the MR and ANN models when tested against independent data as used in the validation tests (see also Figure 10.1). The performance of the MR and ANN models was compared based on the magnitude of MAD and MAPE (i.e. in terms of accuracy and consistency) to enable the best model to be selected. Here, MAD is particularly important since it shows the average absolute deviation of the models. Furthermore, the results of chi-square and correlation tests were also compared. Typically, better MAD results were linked to better MAPE results. Both models were consistent as shown by the values of calculated chi-square which were both less than tabulated chi-square. As a whole, the ANN model performed better than the MR model, however, the difference was only marginal.

Some variables identified by the MR model were also identified by the ANN model. However, the levels of importance of those variables identified were found to differ between the models. One respondent attribute, satisfaction arising from client performance in general, was identified as a significant variable in both models highlighting the subjectivity in the architects' assessment. Furthermore, several variables attributed to the capability of the client's representative (including their project management experience and their qualifications and experience) were significant suggesting the need for capable client's representatives for the provision of high levels of architect satisfaction and overall performance.

Table 10.5 Comparison of the MR and ANN models validation

	MR	ANN
MAD	1.37	1.16
MAPE (%)	23.67	19.53
Chi-square test		
Calculated chi-square	7.580	3.853
***Tabulated* = 23.685**		
Correlation test		
Correlation coefficient	0.524	0.796
Probability	0.023	0.000
Preferred Model		✓

Observation of the most important variables identified by both techniques revealed that the satisfaction arising from client performance in general and the capability of client's representative seem to have more impact on architect satisfaction in the MR model. Conversely, the ANN model focused on project attributes, such as type of project, procurement route and type of building.

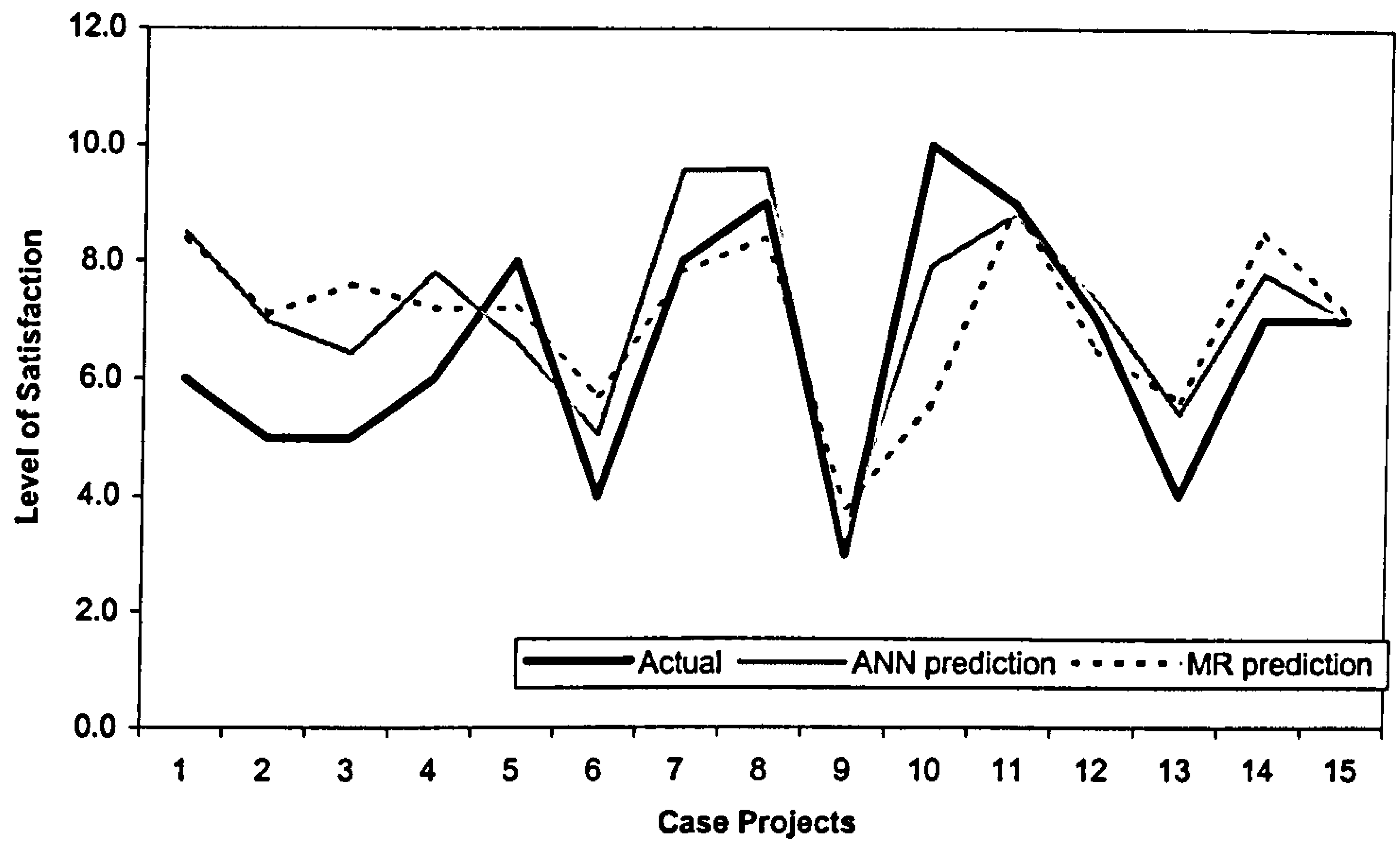


Figure 10.1 Comparison of MR and ANN models' predictions of architects' assessment of client performance

10.3 CONTRACTORS' ASSESSMENT

This section presents the contractors' assessment of client performance. Firstly, the MR and ANN models are discussed including an assessment of their performance and validation, before finally a comparison of the models is presented.

10.3.1 Multiple Regression Results

The MR model was developed to predict and describe contractors' satisfaction levels arising from client performance based on the overall satisfaction measure (*totsat*). The model was investigated for possible violation of the regression assumptions, i.e. normal distribution of residual, equality of variance, and linearity (refer to Appendix I2). The results confirmed that the required assumptions for MR had been met. Results of addressing multicollinearity problems (refer to section 8.3.1) are presented in Appendix

G2. Four combined variables were obtained, namely RSCL16, CLATPPAU, CLATWLSI and CLATFILI. RSCL16, a respondent combined attribute, consisted of RSCLI1 and RSCLI6, and was interpreted as 'perceptions that clients do not know what they want and strive to minimise cost without considering quality'. CLATPPAU comprised CLATTPP, CLATTBU, CLATTSC, CLATTQU, CLATTPM and CLATTAU, and was interpreted as the 'client's past performance and project management / monitoring experience'. CLATWLSI included CLDEPWL, CLATTTY and CLATTSI, and was interpreted as 'construction work load and experience of the client'. CLATFILI consisted of CLATTFI and CLATTLI, and was interpreted as the 'client's financial soundness and reputation for litigation'.

Table 10.6 presents the parameters of the MR model. The model is presented in the following equation:

Overall satisfaction = 1.691 + 0.499 (the qualification and experience of the client's representative)
– 2.157 (the amount of overbudget cost)
+ 0.426 (satisfaction arising from client performance in general)

The model explained 68 percent of the variation in the satisfaction measure (*totsat*). Analysis of variance revealed a significant relationship between the dependent variable and at least one of the independent variables ($F = 36.293$, $p < 0.0005$) indicating that the model was significant. To test the relevancy of each independent variable, a *t*-test was

Table 10.6 Parameters of MR analysis based on contractors' assessment of client performance

Multiple R	0.825
R^2	0.681
Adjusted R^2	0.662
Standard error	1.434

Analysis of Variance

	Sum of Squares	D.F.	Mean Square	F	Sig. F
Regression	223.941	3	74.647	36.293	0.000
Residual	104.895	51	2.057		
Total	328.836	54			

Variables in the Equation

Variable	B	Std. Error	β	t	Sig. t	Tolerance	VIF
(Constant)	1.691	0.758		2.232	0.030		
Qualification and experience of the client's representative	0.499	0.082	0.532	6.067	0.000	0.813	1.230
The amount of overbudget cost	-2.157	0.504	-0.342	-4.277	0.000	0.980	1.020
Satisfaction arising from client performance in general	0.426	0.126	0.295	3.390	0.001	0.827	1.210

applied and revealed that each of the independent variables was a relevant predictor of *totsat* given the presence of the other variables in the model.

The performance of the model was found to be quite good with MAD of 1.05 and MAPE of 28.79% (refer to Table J2.1 in Appendix J) which indicated that the model yielded predicted values with an average deviation of ±1.05, which were 28.79% from actual values. The accuracy and consistency of the model were confirmed by Pearson's correlation test (r = 0.825; $p < 0.0005$) and the chi-square test (calculated chi-square = 18.060 < tabulated chi-square = 72.153).

Validation tests indicated that the model had quite good predictive performance (MAD = 1.42 and MAPE = 28.14%) (refer to Table J2.2 in Appendix J). Overall, the accuracy and consistency of the predicted values were also confirmed by Pearson's correlation test (r = 0.588; p = 0.001) and the chi-square test (calculated chi-square = 11.470 < tabulated chi-square = 36.415).

10.3.1.1 Discussions

A multiple regression model has been developed to predict and describe contractors' satisfaction levels based on client performance. Discussion now follows.

Three independent variables were significant, namely, in descending order of importance, (i) the qualification and experience of the client's representative, (ii) the amount of overbudget cost, and (iii) the satisfaction arising from client performance in general. The client's representative is essential to effective client performance and hence contractor satisfaction. Therefore, careful selection of the client's representative should be an imperative. Contractor satisfaction levels were negated on projects which were overbudget. Here, the more overbudget, the lower levels of contractor satisfaction. This may be connected with the need to commit additional resources and the impact of such problems on the contractors' reputation. The satisfaction arising from client performance in general suggests that contractors' assessment of client performance is affected by their general perception of client performance. This again confirms the subjective nature of performance assessment, in that satisfaction was found to be partly dependent on the perception of contractors.

As a whole, the model identified a mixture of client performance attributes, project attributes and respondent (i.e. assessor) attributes. This indicates that the satisfaction of contractors is not solely dependent on client performance but also on project attributes and contractors' perceptions of clients. This concurs with the conceptual performance assessment model which hypothesised that satisfaction levels are dependent on performance and satisfaction attributes. However, the model developed has to be interpreted with caution since it explained approximately 68 percent of the variation in satisfaction levels. The remaining 32 percent of the variation was unexplained suggesting that in some cases the accuracy of the model may be in doubt. Generally, the model suggests these three independent variables were useful in predicting levels of contractor satisfaction.

10.3.2 Artificial Neural Network Results

An artificial neural network model was developed to predict levels of contractor satisfaction based on client performance. Table 10.7 shows the network typologies for the first and second stage models. Based on the results of the first stage model, insensitive independent variables were pruned by sensitivity analysis. The remaining variables were used to develop the second stage model. The second stage model was then used to predict satisfaction levels. Table 10.8 depicts the independent variables used to predict contractor satisfaction levels in descending order of importance based on the results of the sensitivity analysis (for calculations, refer to Appendix K2).

Table 10.7 Network typology for first and second stage models of contractors' assessment of client performance

Network and learning parameter	First stage model	Second stage model
Type of input variables	Continuous and binary	
Type of output variables	Continuous	
Number of hidden layer	1	1
No. of PEs in input layer	53	18
No. of PEs in hidden layer	10	11
No. of PEs in output layer	1	1
Transfer function	TanhAxon	
Network connectivity	Fully connected	
Learning law	Backpropagation	
Learning algorithm	Momentum	
Step size	0.4, 0.1	0.4, 0.1
Momentum	0.5	0.5
Minimum Mean Square Error	0.0048	0.0098
No. of training epochs	106	135

The performance of the model was good with MAD of 0.46 and MAPE of 11.32% (refer to Table L2.1 in Appendix L). Furthermore, correlation (r = 0.967; $p < 0.0005$) and chi-square (calculated chi-square = 4.483 < tabulated chi-square = 72.153) tests confirmed the accuracy and consistency of the model. Pearson's correlation coefficient ($r = 0.967$) and calculated chi-square (4.483) indicated that the model had been successfully trained and was able to learn the problem. Subsequent validation tests against independent variables showed that the model had MAD of 1.44 and MAPE of 30.46% (refer to Table L2.2 in Appendix L). Correlation ($r = 0.646$; $p < 0.0005$) and chi-square (calculated chi-square = 11.417 < tabulated chi-square = 36.415) tests confirmed that the model was valid and robust.

Table 10.8 Total sensitivity factors (TSFs) for sensitive independent variables identified from the contractors' assessment of client performance

Attributes	Total Sensitivity factor	Ranking
Project overrun	0.6668	1
Overbudget cost	0.5786	2
Procurement route	0.2976	3
Type of building	0.2972	4
Project overbudget	0.2781	5
Type of project	0.2671	6
Nature of client business	0.2644	7
Qualification and experience of the client's representative	0.2380	8
Satisfaction arising from client performance in general	0.1346	9

10.3.2.1 Discussions

Of the 53 independent variables, 18 (including some dummy variables) were identified as useful predictors in the contractor satisfaction model. These were aggregated to arrive at 9 variables. These variables were ranked according to their importance (i.e. TSFs) (refer to Table 10.8).

The model highlighted that project overrun and/or overbudget to be important variables suggesting that contractor satisfaction levels were lowered when projects overrun and/or finished overbudget. This may be due to the need to commit additional resources and the impact of project overrun and/or overbudget on a contractor's track record. Procurement route was found to be an important determinant of satisfaction. This may indicate that long-term, relationship based procurement routes, such as partnering and strategic alliances may be superior to traditional competitive tendering routes.

It is interesting to note that different types of buildings and projects as well as different types of clients (i.e. nature of client business) influence satisfaction levels. From the viewpoint of contractors, these are considered uncontrollable attributes, i.e. beyond their influence / responsibility.

The qualification and experience of the client's representative was identified as an important variable. Therefore, it is important that clients select capable representatives in order to promote successful project implementation.

A respondent attribute (the satisfaction arising from client performance in general) was also found to be a sensitive variable suggesting that contractors' assessment of client performance is affected by their perception. This again confirms the subjective nature of performance assessment, in that satisfaction was found to be partly dependent on the perception of contractors. As in the architects' assessment, this attribute was a sensitive variable, however, here, its level of importance was lower. This suggests that, in general, contractors' judgement of performance may be more objective than architects'.

10.3.3 Comparative Analysis

Table 10.9 shows a comparison of the MR and ANN models in terms of their performance against independent data as used in the validation tests (see also Figure 10.2). The performance of the MR and ANN models was compared based on the magnitude of MAD and MAPE (i.e. in terms of accuracy and consistency) to enable the best model to be selected (as explained in section 10.2.3).

Table 10.9 Comparison of the MR and ANN models validation

	MR	ANN
MAD	1.42	1.44
MAPE (%)	28.14	30.46
Chi-square test ***Calculated chi-square*** ***Tabulated* = 36.415**	11.470	11.417
Correlation test ***Correlation coefficient*** ***Probability***	0.588 0.001	0.646 0.000
Preferred Model	✓	

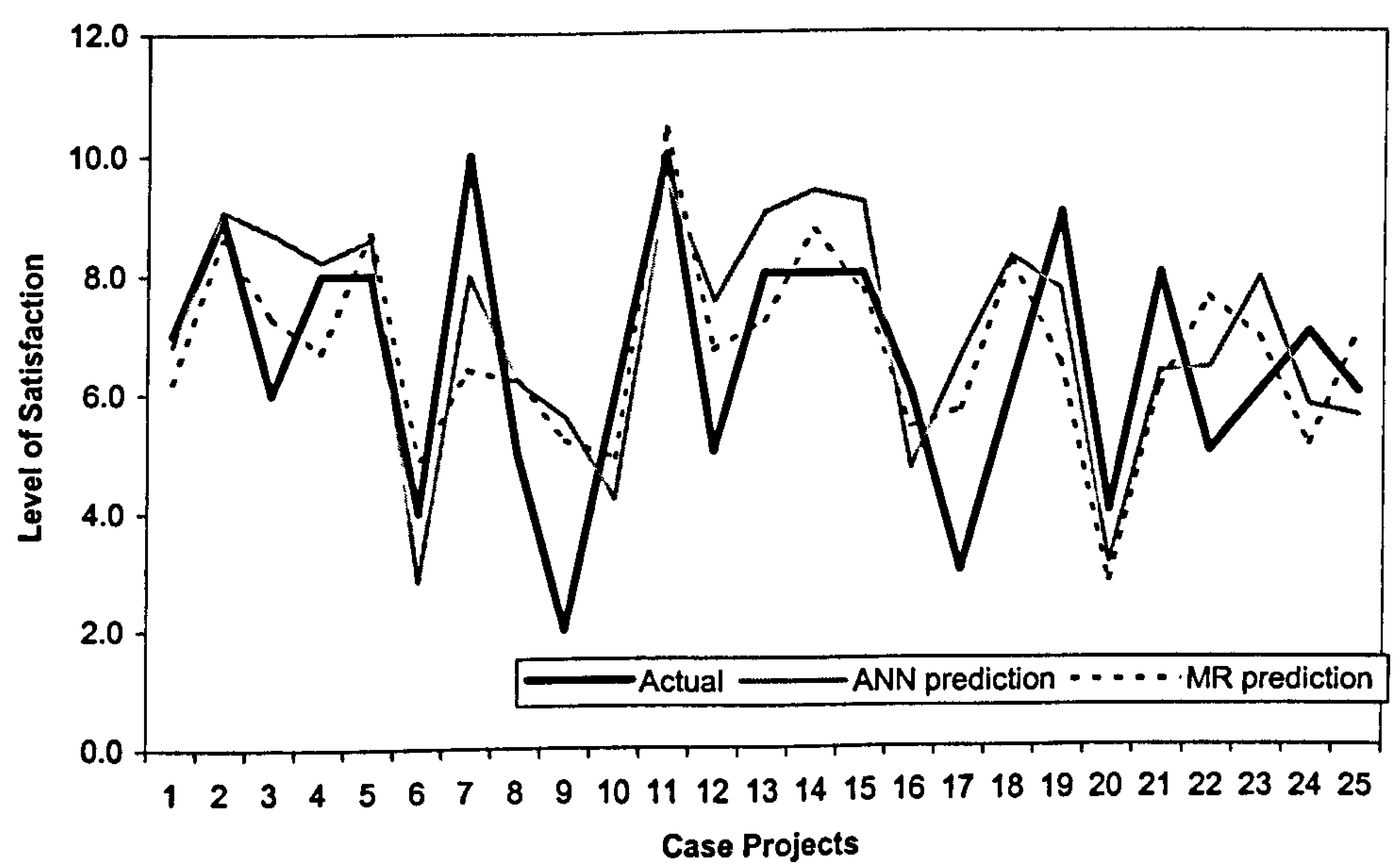


Figure 10.2 Comparison of MR and ANN models' predictions of contractors' assessment of client performance

Evaluation of the models revealed that the MR model was better than the ANN model (refer to Table 10.9), however, the difference was very marginal.

All variables identified by the MR technique were also identified using the ANN technique. The ANN model required more variables than the MR model. Moreover, except for overbudget cost, levels of importance for qualification and experience of the client's representative and the satisfaction arising from client performance in general were found to be relatively low in the ANN model. Instead, the ANN model tended to prioritise project attributes such as project overrun and/or overbudget, and procurement route. These variables are difficult to change or are not dependent solely on clients. However, clients can influence satisfaction levels by selecting suitable procurement routes.

10.4 SUMMARY

This chapter has described the assessment of client performance by architects and contractors. Four models have been developed to predict and describe levels of satisfaction for architects and contractors respectively, using MR and ANN techniques. Each model used the overall satisfaction measure (*totsat*) as the dependent variable and a number of attributes as the independent variables.

For the architects' assessment, the MR model identified the satisfaction arising from client performance in general as the most important independent variable. This suggests that subjectivity is prevalent in the architects' assessment. The ANN model identified type of project as the most important variable. Overall, there were differences between variables identified by both techniques, particularly in terms of their importance and number of variables (i.e. the ANN model used more variables than the MR model). Validation tests showed that these MR and ANN models were valid and robust. However, ANN model was found to be more accurate and consistent than the MR model, although the difference was quite marginal.

For the contractors' assessment, the MR model identified the qualification and experience of the client's representative as the most important independent variable. This suggests that selecting a capable and suitable client's representative could enhance client performance and hence improve contractor satisfaction levels. The ANN model identified project overrun as the most important variable. Generally, there were differences between the variables identified by both techniques, particularly in terms of the importance and number of variables (i.e. the ANN model used more variables than the MR model). Subsequent validation tests showed that these MR and ANN models were valid and robust. However, the MR model was found to be more accurate and consistent than the ANN model, although the difference was very marginal.

Three further conclusions can be drawn from these findings. Firstly, as procurement route was one of the most important variables in the ANN models (ranked second and third in architects' and contractors' assessments respectively), this indicates that the selection of an appropriate procurement route can influence satisfaction levels. Here, findings suggest that long-term relationship-based procurement routes may enhance satisfaction levels. Secondly, a comparison of the importance of variables in both techniques revealed that the variables ranked higher in the MR models were ranked relatively lower in the ANN models. That is, the ANN models tended to highlight the importance of project specific variables such as type of project and procurement route. Finally, a respondent attribute (the satisfaction arising from client performance in general) was identified as an important variable suggesting that some degree of subjectivity is prevalent in performance assessment. Here, the architects' assessment indicated higher levels of subjectivity than those of contractors' (refer to Tables 10.2 and 10.4 for architects', Tables 10.6 and 10.8 for contractors'). This suggests that, in general, contractors' judgement of performance may be more objective than architects'. However, more research is needed to confirm this aspect conclusively. A more detailed interpretation of the main findings presented in this chapter is given in Chapter 13. The next chapter will discuss the assessment of architect performance.

Chapter 11

Modelling Satisfaction Levels Based on Architect Performance

11.1 INTRODUCTION

This chapter discusses the assessment of architect performance by clients and contractors respectively. For each assessment, multiple regression (MR) and artificial neural network (ANN) models are presented, described and finally compared. A more detailed discursive of the main findings reported is presented in Chapter 13. A list of independent variables used to develop the models is presented in Table 11.1.

11.2 CLIENTS' ASSESSMENT

This section presents the clients' assessment of architect performance. Firstly, the MR and ANN models are presented and discussed, including an assessment of their performance and validation. Then, the MR and ANN models are compared.

11.2.1 Multiple Regression Results

A multiple regression model was developed to predict and describe clients' satisfaction of architect performance using the overall satisfaction measure (*totsat*) as the dependent variable. Here, forty-eight cases projects (i.e. respondents) were used. The model was investigated for possible violation of the regression assumptions, i.e. normal distribution of residual, equality of variance, and linearity (refer to Appendix I3). The results confirmed that the required assumptions for MR had been met. Results of analysing the multicollinearity problem (refer to section 8.3.1) are presented in Appendix G3. Two combined variables were obtained, namely RSAR1234 and ARATPPWR. RSAR1234, a

Table 11.1 List of independent variables used to develop the satisfaction models of clients and contractors derived from architect performance

Variable Name	Code	Questionnaire Item	Measure
SATISFACTION ATTRIBUTES			
ASSESSOR			
involved in project	RSPRO	R02	years
involved in similar projects within 5 years	RS5YR	R04	No.
satisfaction on architect performance	RSSATAR	R07	likert 0-10
perception on architect: arrogant	RSARC1	R16	likert 0-10
perception on architect: buildability	RSARC2	R17	likert 0-10
perception on architect: delivery	RSARC3	R18	likert 0-10
perception on architect: management	RSARC4	R19	likert 0-10
perception on architect: technical	RSARC5	R20	likert 0-10
perception on architect: unreliable	RSARC6	R21	likert 0-10
perception on architect: disorganised	RSARC7	R22	likert 0-10
PERFORMANCE ATTRIBUTES			
PROJECT			
type of project	PRTPR (1,2)	P01	nominal
procurement route	PRROU (1,2,3)	P06	nominal
planned duration	PRDURPL	P09	time (months)
overrun	PRDUROV	P10	Yes/No
overrun duration	PRDURTI	P11	time (months)
tender sum	PRBUDTE	P12	Sterling (M)
overbudget	PRBUDOV	P13	Yes/No
overbudget cost	PRBUDMO	P14	Sterling (M)
severity of variations	PRVARSE	P15	likert 0-10
cause of variations by architect	PRVARAR	P18	likert 0-10
design complexity	PRCOMDE	P21	likert 0-10
design completed before work on site	PRDESCO	P23	percentage
constraint by weather conditions	PRCONWE	P26	likert 0-10
remoteness from architect office	PRLOCAR	P30	likert 0-10
interaction between contractor and architect	PRINT	P32	likert 0-10
ARCHITECT			
number of employees	AREMP (1,2,3,4)	A3	ordinal
no. previous project undertaken by architect	ARWKDBF	A5	No.
architect work load	ARWL	A14	likert 0-10
previous relationship with architect personnel	ARPERAR	A18	Yes/No
architect attributes: financial	ARATTFI	A19	likert 0-10
architect attributes: type	ARATTTY	A20	likert 0-10
architect attributes: size	ARATTSI	A21	likert 0-10
architect attributes: past performance	ARATTPP	A24	likert 0-10
architect attributes: time reputation	ARATTSC	A25	likert 0-10
architect attributes: cost reputation	ARATTBU	A26	likert 0-10
architect attributes: quality reputation	ARATTQU	A27	likert 0-10
architect attributes: litigation	ARATTLI	A28	likert 0-10
architect attributes: director / principal	ARATTDI	A30	likert 0-10
architect attributes: project architect	ARATTSP	A31	likert 0-10
architect attributes: quality assurance	ARATTQC	A32	likert 0-10
architect attributes: working relationship	ARATTWR	A33	likert 0-10

respondent attribute, included general perception that architects 'do not listen to views of other coalition members' (RSARC1), are 'more interested in design aesthetics than buildability' (RSARC2), are 'unable to meet deadlines (late information delivery)' (RSARC3), and have 'poor management skills' (RSARC4). ARATPPWR comprised ARATTPP, ARATTSC, ARATTBU and ARATTWR, and was interpreted as 'past performance of architect and the quality of previous working relationship with client'. This suggests that the working relationship concurs with past performance because good past performance may derive repeat works and hence good working relationship.

Table 11.2 presents the parameters of the model. The model could be mathematically presented in the following equation:

Overall satisfaction = 6.829 + 0.488 (the qualification and experience of the project architect)
– 0.314 (severity of variations)
– 0.915 (project overbudget)
– 0.148 (project overbudget cost)
– 0.195 (relevant experience in the type of project)

The coefficient of determination (R^2) was 0.804 indicating that about 80% of the variation in the overall satisfaction was explained by these variables. Analysis of variance revealed a significant relationship between the dependent variable and at least one of the independent variables ($F = 34.500$, $p = 0.000$). To test the relevancy of each independent variable, a t-test was applied and revealed that each of the independent variables was a

Table 11.2 Parameters of MR analysis based on clients' assessment of architect performance

Multiple R	0.897
R^2	0.804
Adjusted R^2	0.781
Standard error	0.894

Analysis of Variance

	Sum of Squares	D.F.	Mean Square	F	Sig. F
Regression	137.903	5	27.581	34.500	0.000
Residual	33.576	42	0.799		
Total	171.479	47			

Variables in the Equation

Variable	B	Std. Error	β	t	Sig. t	Tolerance	VIF
(Constant)	6.829	0.951		7.184	0.000		
Severity of variations	-0.314	0.059	-0.431	-5.362	0.000	0.721	1.387
The qualification and experience of the project architect	0.488	0.081	0.448	6.007	0.000	0.836	1.196
Project overbudget	-0.915	0.283	-0.240	-3.235	0.002	0.846	1.182
Project overbudget cost	-0.148	0.062	-0.181	-2.397	0.021	0.819	1.222
Relevant experience in the type of project	-0.195	0.084	-0.167	-2.333	0.025	0.914	1.094

relevant predictor of the overall satisfaction given the presence of the other variables in the model.

The performance of the model was found to be good with MAD of 0.65 and MAPE of 10.91% which indicated that the model yielded predicted values with an average deviation of ±0.65, which were 10.91% from actual values (refer to Table J3.1 in Appendix J). The accuracy and consistency of the model were confirmed using Pearson's correlation test (r = 0.896; $p < 0.0005$) and the chi-square test (calculated chi-square = 5.287 < tabulated chi-square = 64.001).

Model validation indicated quite good predictive performance (MAD = 1.32 and MAPE = 21.35%) (refer to Table J3.2 in Appendix J). Overall, the accuracy and consistency of the predicted values were also confirmed by Pearson's correlation test (r = 0.453; p = 0.020) and the chi-square test (calculated chi-square = 8.809 < tabulated chi-square = 31.410).

11.2.1.1 Discussions

A multiple regression model has been developed to predict and describe clients' satisfaction levels based on architect performance. The model is now discussed in the following paragraphs.

Five independent variables, including two architect and three project attributes, were included in the model as good predictors of the overall satisfaction. They were, in descending order of importance, (i) the qualification and experience of the project architect, (ii) severity of variations, (iii) project overbudget, (iv) overbudget cost, and (v) relevant experience in the type of project. All variables with the exception of the qualification and experience of the project architect, were found to negatively influence satisfaction levels. One architect performance attribute representing the qualification and experience of the project architect, was found to be the most important variable, highlighting the importance of the project architect, as being key towards achieving client satisfaction as well as architect performance. Therefore, architectural practices should attempt to select and assign capable project architects to represent their companies on construction projects. It is of no real surprise that client satisfaction levels are affected when projects are overbudget and are subject to many variations. It is quite surprising that relevant experience in similar projects was found to lower satisfaction levels. Further examination failed to confirm the presence of multicollinearity (Tolerance = 0.914 and Variance Inflation Factor / VIF = 1.094)[1]. More research is needed to investigate this aspect.

11.2.2 Artificial Neural Network Results

An ANN model was developed to predict levels of client satisfaction based on architect performance. Table 11.3 shows the network typologies for the first and second stage models. Based on the results of the first stage model, insensitive independent variables were pruned. The remaining variables were used to develop the second stage model. The second stage model was then used to predict satisfaction levels. Table 11.4 presents the independent variables used to predict client satisfaction levels in descending order of importance based on the results of the sensitivity analysis (for calculations, refer to Appendix K3). This model is now discussed.

[1] The presence of multicollinearity may reverse the sign of variable coefficients which may not fit in with prior / common knowledge. Tolerance and Variance Inflation Factor (VIF) could be used to detect this problem. The value of tolerance is between 0 to 1 (values near 0 indicates the presence of the problem and near 1 indicates the absence of this). The value of VIF should be 1 or larger. VIF value near 1 indicates the absence of this problem and VIF larger than 10 indicates the presence of this problem.

Table 11.3 Network typology for first and second stage models of clients' assessment of architect performance

Network and learning parameter	First stage model	Second stage model
Type of input variables	Continuous and binary	
Type of output variables	Continuous	
Number of hidden layer	1	1
No. of PEs in input layer	44	15
No. of PEs in hidden layer	5	5
No. of PEs in output layer	1	1
Transfer function	TanhAxon	
Network connectivity	Fully connected	
Learning law	Backpropagation	
Learning algorithm	Momentum	
Step size	0.4, 0.1	0.3, 0.1
Momentum	0.5	0.6
Minimum Mean Square Error	0.0078	0.0099
No. of training epochs	132	180

Table 11.4 Total sensitivity factors (TSFs) for sensitive independent variables identified from the clients' assessment of architect performance

Attributes	Total Sensitivity factor	Ranking
Project overrun	0.7903	1
Poject overbudget	0.2688	2
Any previous working relationship with the project architect	0.2440	3
Number of employees in the architectural practice	0.2032	4
Type of project	0.1532	5
Severity of variations	0.1419	6
Satisfaction arising from architect performance in general	0.0950	7
Perception that architects possess 'poor management skills'	0.0849	8
Procurement route	0.0770	9
The qualification and experience of the project architect	0.0585	10
The architect's reputation in terms of adherence to budget	0.0483	11
The architect's reputation in terms of design quality	0.0479	12
Perception that architects are 'unreliable'	0.0142	13

The performance of the model was very good with MAD of 0.38 and MAPE of 6.04% which indicated that the model yielded predicted values with an average deviation of ±0.38, which were 6.04% from actual values (refer to Table L3.1 in Appendix L). Furthermore, correlation (r = 0.966; p < 0.0005) and chi-square (calculated chi-square = 1.727 < tabulated chi-square = 64.001) tests confirmed the accuracy and consistency of the model. Pearson's correlation coefficient (r = 0.966) and calculated chi-square (1.727) indicated that the model had been successfully trained and was able to learn the problem. Subsequent validation tests showed that the model had MAD of 1.16 and MAPE of 17.68% (refer to Table L3.2 in Appendix L) indicating quite good predictive performance. Correlation (r = 0.532; p = 0.007) and chi-square (calculated chi-square = 10.990 < tabulated chi-square = 31.410) tests confirmed the accuracy and consistency of the model when tested against independent data.

11.2.2.1 Discussions

Of the 44 independent variables, 15 (including some dummy variables) were identified as useful predictors in the client satisfaction model. These were aggregated to arrive at 13 variables which were then ranked according to their importance (i.e. TSFs) (refer to Table 11.4).

Project overrun and overbudget were the two most important variables. These suggest that clients are less satisfied when projects overrun and are overbudget. Any previous working relationship with the project architect may help to improve satisfaction levels. This suggests that repeat clients are more likely to be satisfied than one-off clients. Hence, long-term, relationship-based procurement routes, such as partnering and strategic alliances may have advantages over traditional competitive tendering routes.

It is interesting to note that the size of the architectural practice (i.e. number of employees) affected client satisfaction levels. Perhaps, the size of the practice reflects the amount of resources available, and therefore may influence architect performance and hence client satisfaction. Client satisfaction levels were also affected by project type. It is of no real surprise that variations influence satisfaction levels since most variations are detrimental to project performance.

Several satisfaction attributes were identified as sensitive variables, namely (i) the satisfaction arising from architect performance in general, and perceptions that architects (ii) possess 'poor management skills' and (iii) are 'unreliable'. These indicate that clients who have a good perception of architect performance are more likely to be satisfied. This also suggests that some degree of subjectivity exists in the clients' assessment.

Several architect performance attributes were also identified as sensitive variables, namely (i) the qualification and experience of the project architect, and the architect's reputation in terms of (ii) adherence to budget and (iii) design quality. The capability of the project architect largely determines architect performance and ultimately has an influence on client satisfaction. Therefore, project architects should be carefully selected. The use of design firms with high repute may enhance client satisfaction levels.

11.2.3 Comparative Analysis

Table 11.5 shows a comparison of the MR and ANN models in terms of their performance against independent data as used in the validation tests (see also Figures 11.1). The performance of the MR and ANN models was compared based on the magnitude of MAD and MAPE (i.e. in terms of accuracy and consistency) to enable the best model to be selected (as explained in section 10.2.3).

Table 11.5 Comparison of the MR and ANN models validation

	MR	ANN
MAD	1.32	1.16
MAPE (%)	21.35	17.68
Chi-square test ***Calculated chi-square*** ***Tabulated* = 31.410**	8.809	10.990
Correlation test ***Correlation coefficient*** ***Probability***	0.453 0.020	0.532 0.007
Preferred Model		✓

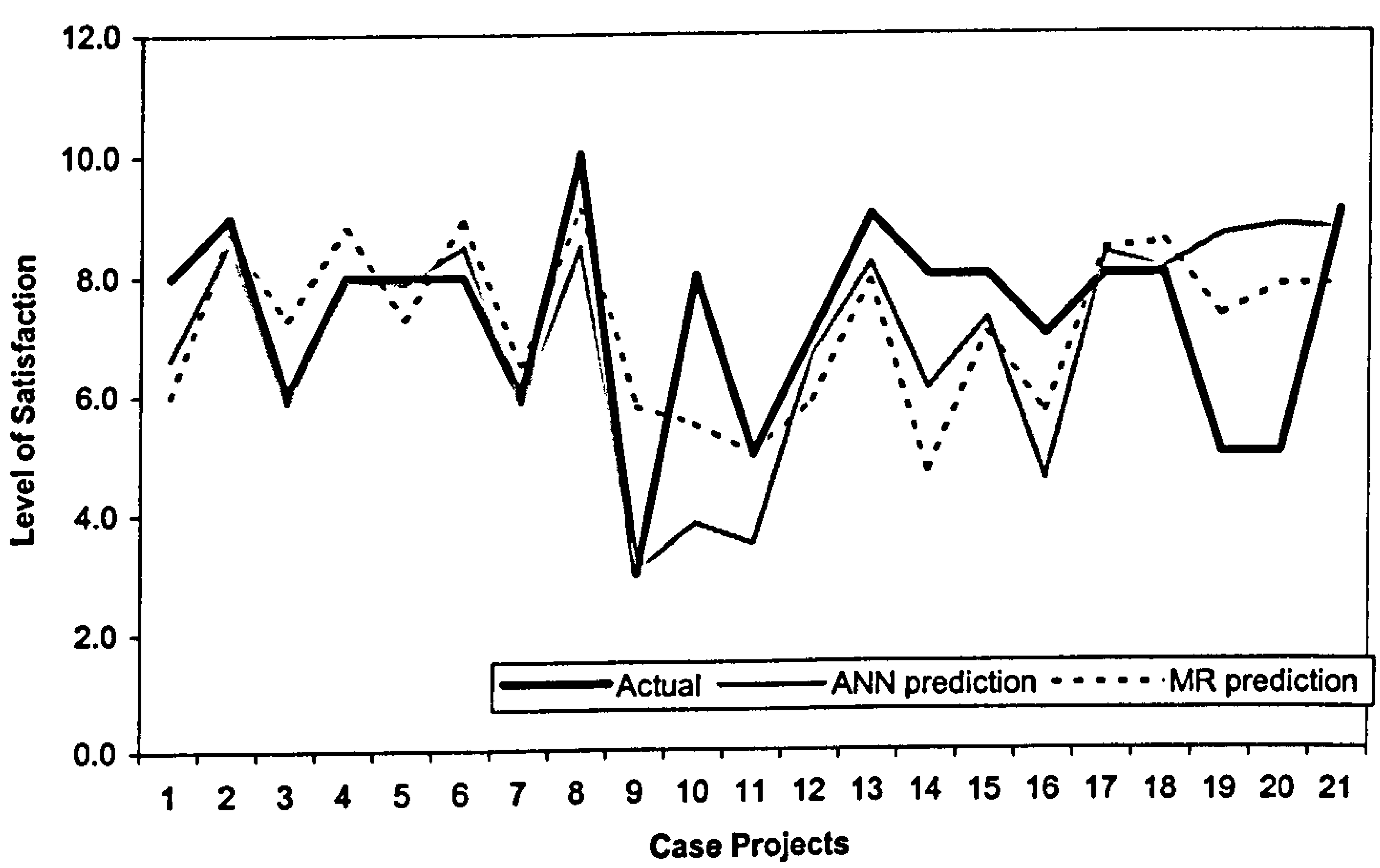


Figure 11.1 Comparison of MR and ANN models' predictions of clients' assessment of architect performance

Evaluation of the models revealed that the performance of the ANN model was better than the MR model, however the difference is quite marginal.

The three most important variables identified by the MR model were also identified by the ANN model, although their levels of importance were different. The most important variable in the MR model, the qualification and experience of the project architect, was only ranked tenth in the ANN model. The ANN model required more variables than the MR model. The ANN model identified a mixture of project attributes, architect performance attributes and respondent (i.e. assessor) attributes. Hence, this suggests that subjectivity is to some extent prevalent in the clients' performance assessment.

While the MR model suggests that capable project architects are the key determinant of client satisfaction, the ANN model suggests project overrun is most important. Moreover, the qualification and experience of the project architect was also a sensitive variable identified by the ANN model although it was only ranked tenth. While this confirms the importance of this variable, this also suggests that architects seem to have more influence on client satisfaction in the MR model than in the ANN model, where the most important variables are not totally within the control of architects. Overall, capable project architects and projects completed on programme seem to be essential for high levels of client satisfaction.

11.3 CONTRACTORS' ASSESSMENT

This section presents the contractors' assessment of architect performance. The MR and ANN models are discussed including an assessment of their performance and validation, before finally a comparison of the models is presented.

11.3.1 Multiple Regression Results

A multiple regression model was developed to predict and describe contractors' satisfaction levels arising from architect performance using the overall satisfaction measure (*totsat*) as the dependent variable. Here, fifty-five case projects were used. The model was investigated for possible violation of the regression assumptions, i.e. normal distribution of residual, equality of variance, and linearity (refer to Appendix I4). The results confirmed that the required assumptions for MR had been met. Analysis of multicollinearity (refer to section 8.3.1) is presented in Appendix G4. Four combined variables were obtained, namely RSAR12, RSAR367, ARATSCBU and ARATPPDI. RSAR12 consisted of RSARC1 and RSARC2 representing general perception that architects 'do not listen to views of other coalition members' and are 'more interested in design aesthetics than buildability'. RSAR367 included RSARC3, RSARC6 and RSARC7 representing general perception that architects are 'unable to meet deadlines (late information delivery)', 'unreliable', and 'disorganised'. ARATSCBU comprised ARATTSC and ARATTBU representing the 'architect's reputation (i.e. past performance) in terms of adherence to schedule and budget'. ARATPPDI included ARATTPP and ARATTDI representing 'past performance in general and capability of director'.

Table 11.6 presents the parameters of the MR model. The model could be mathematically presented in the following equation:

Overall satisfaction = – 2.877 + 0.566 (the qualification and experience of the project architect)
+ 0.245 (the quality of previous working relationship)
+ 0.312 (the architect's reputation in terms of adherence to schedule and budget)
– 1.205 (project overrun)
+ 0.248 (the architect's reputation in terms of design quality)
+ 0.134 (the extent to which the project is constrained by weather conditions)

The model explained 81 percent of the variations in the satisfaction measure. Analysis of variance revealed a significant relationship between the dependent variable and at least one of the independent variables ($F = 33.572$, $p < 0.0005$) indicating that the model was significant. To test the relevancy of each independent variable, a t-test was applied and revealed that each of the independent variables is a relevant predictor of *totsat* given the presence of the other variables in the model.

The performance of the model was found to be good with MAD of 0.82 and MAPE of 18.67% which indicated that the model yielded predicted values with an average deviation of ±0.82, which were 18.67% from actual values (refer to Table J4.1 in Appendix J). The accuracy and consistency of the model were confirmed by Pearson's correlation test (r = 0.898; $p < 0.0005$) and the chi-square test (calculated chi-square = 11.228 < tabulated chi-square = 72.153). Validation tests indicated that the model had quite good predictive performance (MAD = 1.24 and MAPE = 20.63%) (refer to Table J4.2 in Appendix J).

Table 11.6 Parameters of MR analysis based on contractors' assessment of architect performance

Multiple R	0.899
R^2	0.808
Adjusted R^2	0.784
Standard error	1.139

Analysis of Variance

	Sum of Squares	D.F.	Mean Square	F	Sig. F
Regression	261.151	6	43.525	33.572	0.000
Residual	62.231	48	1.296		
Total	323.382	54			

Variables in the Equation

Variable	B	Std. Error	β	t	Sig. t	Tolerance	VIF
(Constant)	-2.877	0.992		-2.901	0.006		
The architect's reputation in terms of adherence to schedule and budget	0.312	0.106	0.249	2.940	0.005	0.557	1.795
The qualification and experience of the project architect	0.566	0.109	0.407	5.205	0.000	0.657	1.523
The quality of previous working relationship	0.245	0.062	0.279	3.932	0.000	0.799	1.252
Project overrun	-1.205	0.319	-0.248	-3.780	0.000	0.929	1.076
The extent to which the project is constrained by weather conditions	0.134	0.058	0.150	2.336	0.024	0.968	1.033
The architect's reputation in terms of design quality	0.248	0.118	0.154	2.100	0.041	0.744	1.345

Overall, the accuracy and consistency of the predicted values were also confirmed by Pearson's correlation test ($r = 0.698$; $p = 0.001$) and the chi-square test (calculated chi-square = 13.554 < tabulated chi-square = 27.587).

11.3.1.1 Discussions

A multiple regression model has been developed to predict and describe contractors' satisfaction levels based on architect performance. Discussion now follows.

The qualification and experience of the project architect was the most important variable suggesting that capable project architects are essential for enhanced contractor satisfaction and project performance. However, the quality of previous working relationships between the architect and the contractor must also be reasonable to achieve this aim.

The significance of several architect performance attributes related to reputation suggests that contractors are more satisfied when working with design practices of high repute. Here, architects need to deliver information on time, keep to budget and produce designs of high quality.

Two project attributes were significant, namely project overrun and the extent to which the project is constrained by weather conditions. Contractor satisfaction levels were negated on projects which were late. It is rather surprising that the extent to which the project is constrained by weather conditions enhances satisfaction levels. Perhaps, participants may be well aware of the impact of UK weather on successful project implementation, and therefore, take necessary actions to mitigate such problems. This may diminish the negative impact of weather on project implementation.

11.3.2 Artificial Neural Network Results

An artificial neural network model has been developed to predict levels of contractor satisfaction based on architect performance. Table 11.7 shows the network typologies for the first and second stage models. Based on the results of the first stage model, insensitive independent variables were pruned using sensitivity analysis. The remaining variables were used to develop the second stage model. The second stage model was then used to predict satisfaction levels. Table 11.8 depicts the independent variables used to predict contractor satisfaction levels in descending order of importance based on the results of the sensitivity analysis (for calculations, refer to Appendix K4).

The performance of the model was good with MAD of 0.51 and MAPE of 10.86% (refer to Table L4.1 in Appendix L). Furthermore, correlation ($r = 0.965$; $p < 0.0005$) and chi-square (chi-square = 4.276 < tabulated chi-square = 72.153) tests confirmed the accuracy and consistency of the model. Pearson's correlation coefficient ($r = 0.965$) and calculated chi-square (4.276) indicated that the model had been successfully trained and was able to learn the problem. Subsequent validation tests against independent variables showed that the model had MAD of 1.04 and MAPE of 17.61% (refer to Table L4.2 in Appendix L). Correlation ($r = 0.809$; $p = 0.000$) and chi-square (calculated chi-square = 7.964 < tabulated chi-square = 27.587) tests confirmed that the model was valid and robust.

Table 11.7 Network typology for first and second stage models of contractors' assessment of architect performance

Network and learning parameter	First stage model	Second stage model
Type of input variables	Continuous and binary	
Type of output variables	Continuous	
Number of hidden layer	1	1
No. of PEs in input layer	45	14
No. of PEs in hidden layer	6	6
No. of PEs in output layer	1	1
Transfer function	TanhAxon	
Network connectivity	Fully connected	
Learning law	Backpropagation	
Learning algorithm	Momentum	
Step size	0.3, 0.1	0.3, 0.1
Momentum	0.5	0.5
Minimum Mean Square Error	0.0049	0.0100
No. of training epochs	160	393

11.3.2.1 Discussions

Of the 45 independent variables, 14 (including some dummy variables) were identified as useful predictors in the contractor satisfaction model. There were aggregated to arrive at 11 variables. These variables were then ranked based on their importance (TSFs) (refer to Table 11.8). They are now discussed in the following paragraphs.

Procurement route was the most important variable in the model. It was followed by any previous working relationship with the project architect. These suggest that long-term relationships, especially at personnel level, would encourage higher contractor satisfaction levels. Hence, partnering and strategic alliances may have advantages over traditional routes, e.g. competitive tendering.

Table 11.8 Total sensitivity factors (TSFs) for sensitive independent variables identified from the contractors' assessment of architect performance

Attributes	Total Sensitivity factor	Ranking
Procurement route	0.9185	1
Any previous working relationship with the project architect	0.5377	2
Project overrun	0.4595	3
Type of project	0.2829	4
The architect's reputation in speed of information delivery	0.2710	5
The qualification and experience of the project architect	0.2170	6
The extent of variations caused by architect	0.1873	7
The architect's past performance in general	0.1786	8
Overbudget cost	0.1188	9
Current workload	0.0884	10
The qualification and experience of director	0.0210	11

Project overrun and overbudget were identified as sensitive variables. These may indicate that contractors are dissatisfied when projects are delivered late and overbudget. It is surprising to find that contractors consider project type to be an important determinant of their satisfaction. Here, project type is considered somewhat uncontrollable (i.e. beyond the control of contractors and architects).

Several architect performance attributes were identified as sensitive variables including their reputation in speed of information delivery, the qualification and experience of the project architect, past performance in general, current workload and the qualification and experience of their director. These may suggest that architects with a good track record are more likely to satisfy contractors. It is of no real surprise that the capability of the project architect and director (i.e. partner) was found to be important since capable project architects and partners enable contractors to perform better and thereby improve satisfaction levels. Moreover, such key persons largely determine the performance of the architect. Current workload may indicate that excessive workloads can hamper architect performance and hence influence satisfaction levels. In addition to these, the model also identified the extent of variations caused by architects as a sensitive variable. Although from the contractors' viewpoint, variations may provide opportunity to increase profits, variations cause poor project performance and also discourage contractor performance.

11.3.3 Comparative Analysis

Table 11.9 shows a comparison of the MR and ANN models in terms of their performance against independent data as used in the validation tests (see also Figure 11.2). The performance of the MR and ANN models was compared based on the magnitude of MAD and MAPE (i.e. in terms of accuracy and consistency) to enable the best model to be selected (as explained in section 10.2.3).

Evaluation of the models revealed that the ANN model was better than the MR model (refer to Table 11.9), however, the difference was relatively marginal.

Three variables identified by the MR model were also identified by the ANN model, although levels of importance were found to differ. The ANN model required more variables than the MR model. Furthermore, no respondent attributes were identified by the ANN model in contrast to the client satisfaction model where three respondent attributes were found to be of important. That is, a higher level of objectivity is apparent in the contractors' assessment.

Table 11.9 Comparison of the MR and ANN models validation

	MR	ANN
MAD	1.24	1.04
MAPE (%)	20.63	17.61
Chi-square test		
Calculated chi-square	13.554	7.964
***Tabulated* = 27.587**		
Correlation test		
Correlation coefficient	0.698	0.809
Probability	0.001	0.000
Preferred Model		✓

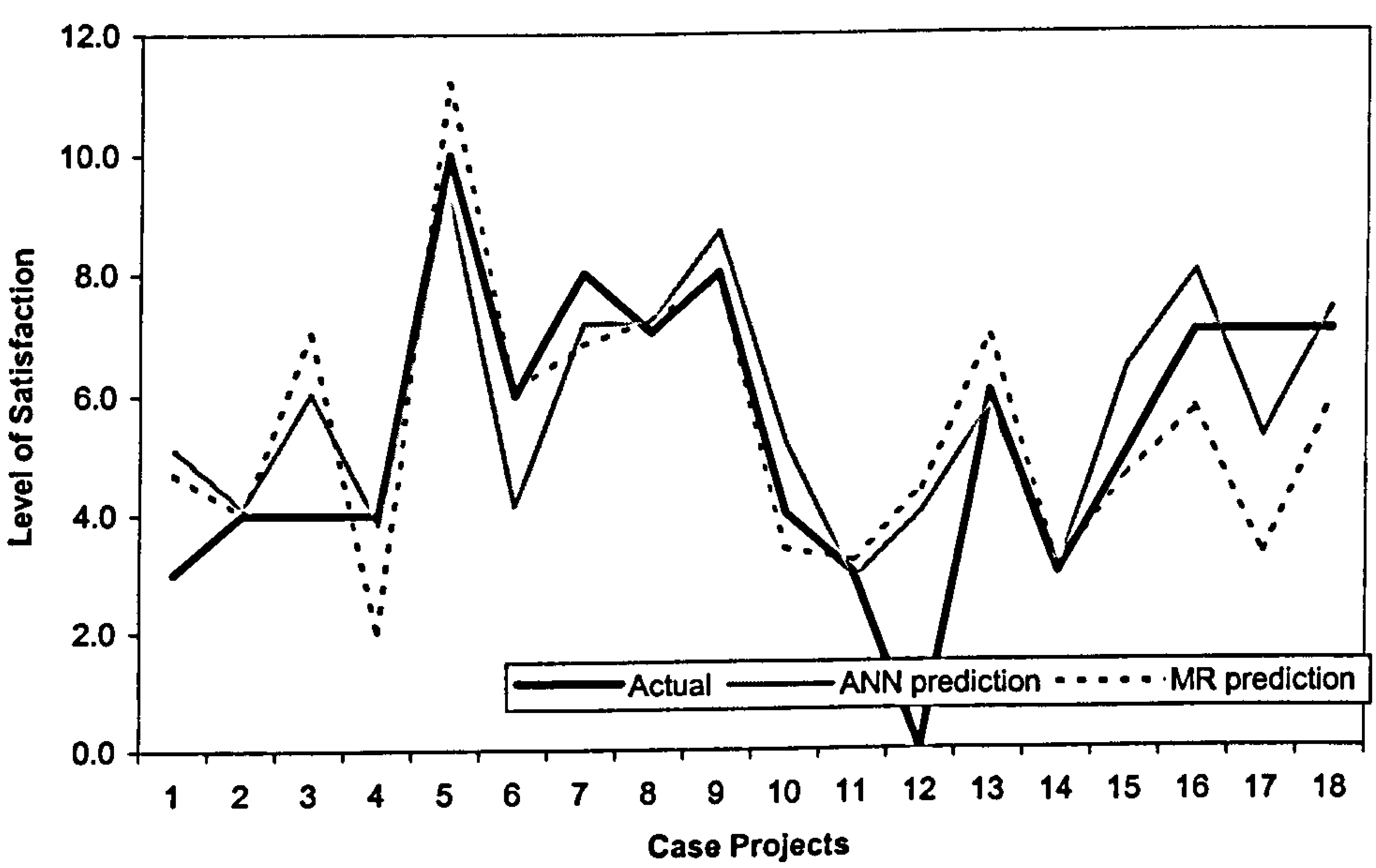


Figure 11.2 Comparison of MR and ANN models' predictions of contractors' assessment of architect performance

The MR and ANN models suggest that capable project architects and the selection of an appropriate procurement route respectively are key determinants of contractor satisfaction. Moreover, the importance of the project architect was reinforced by the ANN model (ranked sixth). Architects seem to have less influence on contractor satisfaction levels in the ANN model since the most important variables were largely beyond their control. Conversely, several architect performance attributes were the most important variables in the MR model. Overall, capable project architects and long-term, relationship-based procurement routes seem to be essential for high levels of contractor satisfaction.

11.4 SUMMARY

This chapter has described the assessment of architect performance by their clients and contractors. Several models have been developed to predict and describe levels of satisfaction for clients and contractors respectively, using MR and ANN techniques. The models used the overall satisfaction measure (*totsat*) as the dependent variable and a number of attributes as the independent variables.

For the clients' assessment, the MR and ANN models identified the capability of the project architect and project overrun as the most important independent variables respectively. These findings suggest that capable project architects and projects delivered on or before programme seem to be essential for high levels of client satisfaction. Some differences were found between the two modelling techniques, particularly in terms of the importance and number of variables (i.e. the ANN model used more variables than the MR model). Validation tests showed that the MR and ANN models were valid and robust. However, the ANN model was found to be more accurate and consistent, although this difference was quite marginal.

For the contractors' assessment, the qualification and experience of the project architect and procurement route were found to be the most important variables for the MR and ANN models respectively. In the ANN model, any previous working relationship with the project architects was the second most important variable. These suggest that capable project architects and long-term, relationship-based procurement routes seem to be essential for high levels of contractor satisfaction. Fifty percent of the variables identified by the MR model were also identified by the ANN model, although levels of importance for such variables were found to differ. Subsequent validation tests showed that these MR and ANN models were valid and robust. However, the MR model was found to be marginally more accurate and consistent than the ANN model.

Three further conclusions can be drawn from the modelling of contractor and client satisfaction levels. Firstly, the qualification and experience of the project architect was identified by the MR models as the most important variable for both clients and contractors. This was further supported by the ANN models and highlights the crucial role that the project architect plays in the project coalition. Additionally, the most important variables identified by the ANN model for contractors suggest that long-term relationships may enhance satisfaction levels. This was also supported by findings of the ANN client satisfaction model which identified previous working relationships with the project architects as the third most important variable. Secondly, a comparison of the importance of variables in both techniques revealed that architects seem to have more impact on satisfaction levels in the MR models. Thirdly, subjectivity while present to some extent, was relatively low. Satisfaction attributes were only identified by the ANN client satisfaction model. This indicates that generally, the clients' assessment may be more subjective than the contractors'. A more detailed interpretation of the main findings presented in this chapter is given in Chapter 13. The next chapter will discuss the assessment of contractor performance.

Chapter 12

Modelling Satisfaction Levels Based on Contractor Performance

12.1 INTRODUCTION

This chapter discusses the assessment of contractor performance by clients and architects respectively. For each assessment, multiple regression (MR) and artificial neural network (ANN) models are presented, described, and finally compared. A more detailed discursive of the main findings reported is presented in Chapter 13. A list of independent variables used to develop the models is presented in Table 12.1.

12.2 CLIENTS' ASSESSMENT

This section presents the clients' assessment of contractor performance. Firstly, the MR and ANN models are presented and discussed, including an assessment of their performance and validation. Then, the ANN and MR models are compared.

12.2.1 Multiple Regression Results

A multiple regression model was developed to predict and describe client satisfaction levels using the overall satisfaction measure (*totsat*). Here, fifty case projects (i.e. respondents) were used. The model was investigated for possible violation of the regression assumptions, i.e. normal distribution of residual, equality of variance, and linearity (refer to Appendix I5). The results confirmed that the required assumptions for MR had been met. The results of investigating the presence of multicollinearity (refer to section 8.3.1) are presented in Appendix G5. Six combined variables were obtained, namely RSCO24, RSCO57, COATPPQU, COATFISI, COATSULA and COATLIIM. RSCO24 included several respondent attributes representing general perceptions that

Table 12.1 List of independent variables used to develop the satisfaction models of clients and architects derived from contractor performance

Variable Name	Code	Questionnaire Item	Measure
SATISFACTION ATTRIBUTES			
ASSESSOR			
satisfaction on contractor performance	RSSATCO	R08	likert 0-10
perception on contractor claims	RSCON2	R24	likert 0-10
perception on contractor on time	RSCON3	R25	likert 0-10
perception on contractor contractual	RSCON4	R26	likert 0-10
perception on contractor untidy	RSCON5	R27	likert 0-10
perception on contractor inefficient	RSCON6	R28	likert 0-10
perception on contractor technology	RSCON7	R29	likert 0-10
PERFORMANCE ATTRIBUTES			
PROJECT			
type of project	PRTPR (1,2)	P01	nominal
type of building	PRTBD (1,2,3,4)	P02	nominal
number of storeys	PRSTO	P03	No.
procurement route	PRROU (1,2,3)	P06	nominal
planned duration	PRDURPL	P09	time (months)
overrun	PRDUROV	P10	Yes/No
overrun duration	PRDURTI	P11	time (months)
tender sum	PRBUDTE	P12	Sterling (M)
overbudget	PRBUDOV	P13	Yes/No
overbudget cost	PRBUDMO	P14	Sterling (M)
severity of variations	PRVARSE	P15	likert 0-10
cause of variations by contractor	PRVARCO	P19	likert 0-10
design complexity	PRCOMDE	P21	likert 0-10
constraint by ground conditions	PRCONGR	P25	likert 0-10
constraint by weather conditions	PRCONWE	P26	likert 0-10
ease of access to project location	PRLOCAC	P28	likert 0-10
interaction between contractor and architect	PRINT	P32	likert 0-10
CONTRACTOR			
method of contractor selection	COSELCO (1, 2)	O06	nominal
contractor evaluation prior contract award	COEVACL/AR	O13	likert 0-10
architect work load	COWL	O14	likert 0-10
method of contractor payment	COPAYCO (1, 2)	O15	nominal
previous relationship with site personnel	COPERCO	O19	Yes/No
contractor attributes: financial soundness	COATTFI	O20	likert 0-10
contractor attributes: experience in type of proj.	COATTTY	O21	likert 0-10
contractor attributes: experience in size of proj.	COATTSI	O22	likert 0-10
contractor attributes: references	COATTRE	O24	likert 0-10
contractor attributes: past performance	COATTPP	O25	likert 0-10
contractor attributes: time reputation	COATTSC	O26	likert 0-10
contractor attributes: cost reputation	COATTBU	O27	likert 0-10
contractor attributes: quality reputation	COATTQU	O28	likert 0-10
contractor attributes: litigation reputation	COATTLI	O29	likert 0-10
contractor attributes: claim reputation	COATTIM	O30	likert 0-10
contractor attributes: director	COATTDI	O31	likert 0-10
contractor attributes: site personnel	COATTSP	O32	likert 0-10
contractor attributes: health and safety	COATTHS	O33	likert 0-10
contractor attributes: training regime	COATTTR	O34	likert 0-10
contractor attributes: quality control	COATTQC	O35	likert 0-10
contractor attributes: subs and suppliers	COATTSU	O36	likert 0-10
contractor attributes: labour	COATTLA	O37	likert 0-10
contractor attributes: working relationship	COATTWR	O39	likert 0-10

contractors 'are claim conscious' (RSCON2), 'never finish projects on time' (RSCON3), and 'are contractual' (RSCON4). Similarly, RSCO57 covered several respondent attributes representing general perceptions that contractors are 'wasteful / untidy' (RSCON5), 'unproductive / inefficient' (RSCON6), and 'slow in adopting new technology / innovations' (RSCON7). COATPPQU consisted of COATTPP, COATTSC, COATTBU and COATTQU, and was interpreted as 'past performance of contractor in general and in terms of cost, time and quality'. COATFISI comprised COATTFI, COATTTY and COATTSI, and was interpreted as the 'contractor's financial soundness and experience in type and size of project'. COATSULA included COATTSU and COATTLA, and was interpreted as the 'contractor's industrial relations'. COATLIIM comprised COATTLI and COATTIM, and was interpreted as the 'contractor's reputation for litigation and claims'.

Table 12.2 presents the parameters of the model. The model could be expressed in the following equation:

Overall satisfaction = 1.236 + 0.534 (past performance of contractor in general and in terms of cost, time and quality)
+ 0.330 (health and safety past performance and policy)
– 0.219 (the extent of variations caused by contractor)
– 0.195 (project overbudget cost)
+ 0.05465 (planned project duration)
– 0.658 (public building projects)

The model explained 78 percent of the variations in the satisfaction measure. Analysis of variance revealed a significant relationship between the dependent variable and at least

Table 12.2 Parameters of MR analysis based on clients' assessment of contractor performance

Multiple R	0.884
R^2	0.782
Adjusted R^2	0.751
Standard error	0.820

Analysis of Variance

	Sum of Squares	D.F.	Mean Square	F	Sig. F
Regression	103.542	6	17.257	25.643	0.000
Residual	28.938	43	0.673		
Total	132.480	49			

Variables in the Equation

Variable	B	Std. Error	β	t	Sig. t	Tolerance	VIF
(Constant)	1.236	0.966		1.280	0.207		
past performance of contractor in general and in terms of co, ti and qua	0.534	0.122	0.388	4.368	0.000	0.645	1.550
the extent of variations caused by contractor	-0.219	0.062	-0.281	-3.500	0.001	0.790	1.265
health and safety past performance and policy	0.330	0.091	0.316	3.644	0.001	0.677	1.476
project overbudget cost	-0.195	0.057	-0.271	-3.434	0.001	0.815	1.226
planned project duration	0.05465	0.019	0.213	2.805	0.008	0.885	1.130
public building projects	-0.658	0.262	-0.185	-2.516	0.016	0.936	1.068

one of the independent variables ($F = 25.643$, $p < 0.0005$) indicating that the model was significant. To test the relevancy of each independent variable, a t-test was applied and revealed that each of the independent variables was a relevant predictor of *totsat* given the presence of the other variables in the model. However, the result for the constant was not found to be significant ($p = 0.207$), and hence, its inclusion needs further examination.

The performance of the model was found to be good with MAD of 0.61 and MAPE of 9.14% which indicated that the model yielded predicted values with an average deviation of ±0.61, which were 9.14% from actual values (refer to Table J5.1 in Appendix J). The accuracy and consistency of the model were confirmed using Pearson's correlation test ($r = 0.884$; $p < 0.0005$) and the chi-square test (calculated chi-square = 4.164 < tabulated chi-square = 66.338). The performance of the model worsened with the absence of the constant (MAD = 1.26, MAPE = 16.79% and calculated chi-square = 18.063) confirming the use of the previous model (i.e. including constant).

Model validation indicated quite good predictive performance (MAD = 1.37 and MAPE = 26.68%) (refer to Table J5.2 in Appendix J). Overall, the accuracy and consistency of the predicted values were also confirmed by Pearson's correlation test ($r = 0.446$; $p = 0.010$) and the chi-square test (calculated chi-square = 13.417 < tabulated chi-square = 38.885).

12.2.1.1 Discussions

A multiple regression model has been developed to predict and describe levels of client satisfaction based on contractor performance. Discussion now follows.

Six independent variables were significant including, in descending order of importance, (i) past performance of contractor in general and in terms of cost, time and quality, (ii) health and safety past performance and policy, (iii) the extent of variations caused by the contractor, (iv) project overbudget cost, (v) planned project duration, and (vi) public building projects. Contractors whose past performance is good, are more likely to satisfy their clients. Moreover, contractors with a good track record in health and safety are essential for higher levels of client satisfaction.

It is not really surprising that clients become dissatisfied when projects incur many variations and are completed overbudget. Here, the more overbudget cost, the less satisfied clients will be. Therefore, contractors should attempt to reduce variations and keep the project on budget if they are to satisfy their clients. Interestingly, larger projects (i.e. longer planned project duration) were found to raise satisfaction levels. This may be connected to the prestige associated with such projects, and the need to involve well resourced and experienced contractors whose performance may be superior to smaller firms. Clients (i.e. public clients) were found to be less satisfied on public building projects.

12.2.2 Artificial Neural Network Results

An artificial neural network model was developed to predict levels of client satisfaction based on contractor performance. Table 12.3 shows the network typologies for the first and second stage models. Based on the results of the first stage model, insensitive independent variables were pruned. The remaining variables were used to develop the second stage model. The second stage model was then used to predict satisfaction levels. Table 12.4 presents the independent variables used to predict client satisfaction levels in descending order of importance based on the results of the sensitivity analysis (for calculations, refer to Appendix K5).

Table 12.3 Network typology for first and second stage models of clients' assessment of contractor performance

Network and learning parameter	First stage model	Second stage model
Type of input variables	Continuous and binary	
Type of output variables	Continuous	
Number of hidden layer	1	1
No. of PEs in input layer	58	22
No. of PEs in hidden layer	4	5
No. of PEs in output layer	1	1
Transfer function	TanhAxon	
Network connectivity	Fully connected	
Learning law	Backpropagation	
Learning algorithm	Momentum	
Step size	0.5, 0.1	0.5, 0.1
Momentum	0.6	0.6
Minimum Mean Square Error	0.0046	0.0096
No. of training epochs	182	121

The performance of the model was very good with MAD of 0.36 and MAPE of 5.80% which indicated that the model yielded predicted values with an average deviation of ±0.36, which were 5.80% from actual values (refer to Table L5.1 in Appendix L). Furthermore, correlation (r = 0.958; p < 0.0005) and chi-square (calculated chi-square = 1.830 < tabulated chi-square = 66.338) tests confirmed the accuracy and consistency of the model. Pearson's correlation coefficient (r = 0.958) and calculated chi-square (1.830) indicated that the model had been successfully trained and was able to learn the problem. Subsequent validation tests showed that the model had MAD of 1.26 and MAPE of 23.32% (refer to Table L5.2 in Appendix L) indicating quite good predictive performance.

Correlation (r = 0.630; p < 0.0005) and chi-square (calculated chi-square = 10.293 < tabulated chi-square = 38.885) tests confirmed the accuracy and consistency of the model against independent data (i.e. the model was valid and robust).

Table 12.4 Total sensitivity factors (TSFs) for sensitive independent variables identified from the clients' assessment of contractor performance

Attributes	Total Sensitivity factor	Ranking
Project overrun	0.6876	1
Any previous working rel'ship with the contr's site personnel	0.6203	2
Method of contractor selection	0.4368	3
Type of building	0.3237	4
Procurement route	0.3192	5
Past performance in quality of construction	0.2775	6
Method of contractor payment	0.2651	7
The extent of variations caused by contractor	0.2357	8
Project overbudget	0.1558	9
Type of project	0.0835	10
Current work load	0.0601	11

12.2.2.1 Discussions

Of the 58 independent variables, 22 (including some dummy variables) were identified as useful predictors in the client satisfaction model. These were aggregated to arrive at 11 variables. These variables were then ranked according to their importance (i.e. TSFs) (refer to Table 12.4).

Project overrun was identified as the most important variable. This suggests the need to deliver projects on or before programme is essential for higher client satisfaction. In addition to this, project overbudget was a sensitive variable (ranked ninth). Contractors should also maintain their attempts to deliver projects on time and on budget.

Any previous working relationship with the contractor's site personnel was the second most important variable. Here, a well-established working relationship with the contractors' site personnel may produce higher satisfaction levels. Further, the procurement of the contractor must be carefully considered. Due to its adversarial nature, the competitive tendering approach is likely to discourage good performance and hence lower satisfaction levels. In this case, a contractor selection methodology based on negotiation would encourage higher satisfaction levels. These two variables suggest that long-term relationships would encourage higher client satisfaction levels. Procurement route was also ranked fifth indicating the importance of an appropriate procurement route.

It is interesting to note that different types of building and project influence satisfaction levels. In the context of this research, they are considered uncontrollable attributes which can not be altered by members of the PC.

The model also highlighted the need for contractors to deliver quality projects. Method of contractor payment as a significant variable may suggest that the lump sum method of payment may discourage satisfaction in contrast to, for example, cost reimbursement. Here, the method of contractor payment should be carefully considered and negotiated before project commencement. Contractors should attempt to reduce variations since these have an adverse effect on satisfaction.

The contractor's current workload was a sensitive variable (ranked the last). Although an excessive workload can be detrimental to performance, a steady and continuous flow of work may enhance contractor performance through the opportunity to gain more experience, sustain the business financially, and to employ better and adequate resources.

12.2.3 Comparative Analysis

Table 12.5 compares the performance of the MR and ANN models when tested against independent data as used in the validation tests (see also Figures 12.1). The performance of the MR and ANN models was compared based on the magnitude of MAD and MAPE (i.e. in terms of accuracy and consistency) to enable the best model to be selected (as explained in section 10.2.3).

Evaluation of the models revealed that the ANN model was better than the MR model, albeit, this difference was marginal.

The ANN model required more variables than the MR model. Moreover, levels of importance for the variables were found to differ between the two techniques. Only two out of six variables identified by the MR technique were also identified using the ANN technique.

Table 12.5 Comparison of the MR and ANN models validation

	MR	ANN
MAD	1.37	1.26
MAPE (%)	26.68	23.32
Chi-square test		
Calculated chi-square	13.417	10.293
***Tabulated* = 38.885**		
Correlation test		
Correlation coefficient	0.446	0.630
Probability	0.010	0.000
Preferred Model		✓

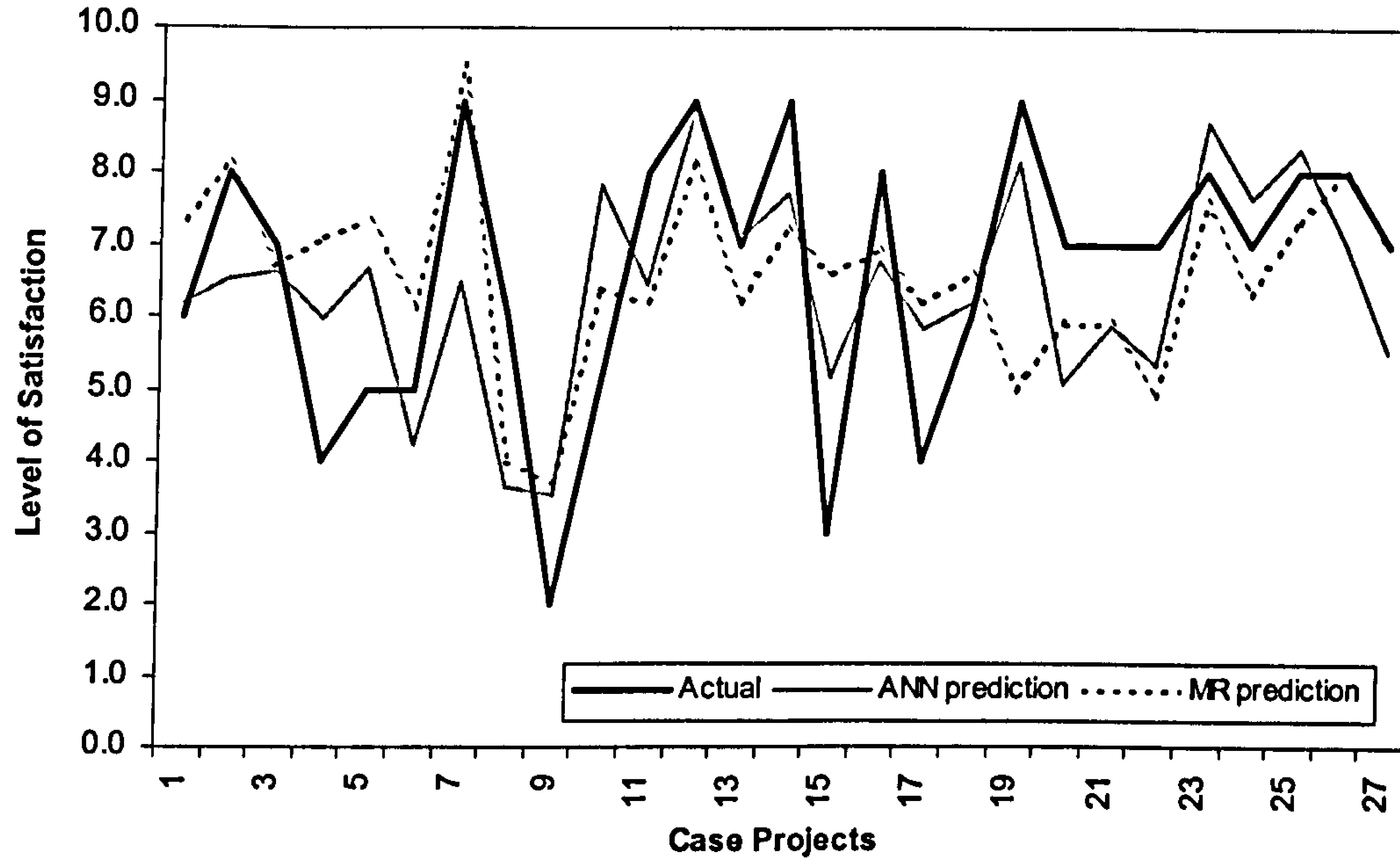


Figure 12.1 Comparison of MR and ANN models' predictions of clients' assessment of contractor performance

A comparison of the importance of variables in both techniques revealed that contractors seem to have more impact on client satisfaction in the MR model. In the MR model, several contractor performance attributes were considered the most important variables. In the ANN model, the most important variables were found to be largely beyond the control of contractors. In sum, while the importance of contractor performance attributes should not be overlooked, clients should also pay particular attention to key project attributes, since these have a highly significant impact on their satisfaction.

12.3 ARCHITECTS' ASSESSMENT

This section presents the findings of the architects' assessment of contractor performance. The MR and ANN models are discussed including an assessment of their performance and validation, before finally a comparison of the models is presented.

12.3.1 Multiple Regression Results

A multiple regression model was developed to predict and describe architects' satisfaction of contractor performance based on the overall satisfaction measure (*totsat*). Here, fifty-four case projects were used. The model was investigated for possible violation of the regression assumptions, i.e. normal distribution of residual, equality of variance, and linearity (refer to Appendix I6). The results confirmed that the required assumptions for MR had been met. Results of addressing the presence of multicollinearity (refer to section 8.3.1) are presented in Appendix G6. Five combined variables were obtained, namely RSCO27, COATPPQU, COATSULA, COATLIIM and COATWLFI. RSCO27, a respondent combined attribute, comprised RSCON2 to RSCON7 representing general perceptions that contractors 'are claim conscious', 'never complete projects on time', 'are contractual', 'are wasteful / untidy', 'are unproductive / inefficient', and 'are slow in adopting new technology / innovations.' COATPPQU consisted of COATTPP, COATTSC, COATTBU and COATTQU, and was interpreted as 'past performance of contractor in general and in terms of cost, time and quality'. COATSULA included COATTSU and COATTLA, and was interpreted as the 'contractor's industrial relations'. COATLIIM comprised COATTLI and COATTIM, and was interpreted as the 'contractor's reputation in litigation and claim'. COATWLFI consisted of COWL and COATTFI, representing 'current workload and financial soundness of contractor'.

Table 12.6 presents the parameters of the MR model. The model could be expressed in the following equation:

Overall satisfaction = – 0.315 + 0.495 (the qualification and experience of site personnel)
+ 0.349 (satisfaction arising from contractor performance in general)
– 1.179 (project overbudget)
+ 0.350 (the contractor's industrial relations)
– 1.363 (contractor selected through two-stage competitive tendering)
– 1.522 (retail building projects)
+ 0.741 (lump sum method of contractor payment)
– 0.08529 (the extent to which the project is constrained by ground conditions)

The model explained 84 percent of the variations in the satisfaction measure. Analysis of variance revealed a significant relationship between the dependent variable and at least one of the independent variables ($F = 30.153$, $p < 0.0005$) indicating that the model was significant. To test the relevancy of each independent variable, a t-test was applied and revealed that each of the independent variables was a relevant predictor of *totsat* given the presence of the other variables in the model. However, the result for the constant was not found to be significant ($p = 0.713$), and hence, its inclusion needs further examination.

Table 12.6 Parameters of MR analysis based on architects' assessment of contractor performance

Multiple R	0.918
R^2	0.843
Adjusted R^2	0.815
Standard error	0.961

Analysis of Variance

	Sum of Squares	D.F.	Mean Square	F	Sig. F
Regression	222.618	8	27.827	30.153	0.000
Residual	41.530	45	0.923		
Total	264.148	53			

Variables in the Equation

Variable	B	Std. Error	β	t	Sig. t	Tolerance	VIF
(Constant)	-0.315	0.851		-0.370	0.713		
The qualification and experience of site personnel	0.495	0.111	0.383	4.453	0.000	0.473	2.112
Project overbudget	-1.179	0.279	-0.264	-4.228	0.000	0.899	1.113
The contractor's industrial relations	0.350	0.089	0.262	3.929	0.000	0.788	1.269
Satisfaction arising from contractor performance in general	0.349	0.105	0.265	3.308	0.002	0.544	1.840
Contractor selected through two-stage competitive tendering	-1.363	0.341	-0.239	-3.995	0.000	0.972	1.028
Retail building projects	-1.522	0.461	-0.199	-3.299	0.002	0.956	1.046
Lump sum method of contractor payment	0.741	0.318	0.147	2.329	0.024	0.880	1.136
The extent to which the project is constrained by ground conditions	-0.08529	0.042	-0.131	-2.028	0.048	0.832	1.202

The performance of the model was found to be good with MAD of 0.71 and MAPE of 11.44% which indicated that the model yielded predicted values with an average deviation of ±0.71, which were 11.44% from actual values (refer to Table J6.1 in Appendix J). The accuracy and consistency of the model were confirmed using Pearson's correlation test (r = 0.918; p < 0.0005) and the chi-square test (calculated chi-square = 5.947 < tabulated chi-square = 70.993). The performance of the model worsened with the absence of the constant (MAD = 0.78, MAPE = 13.53% and calculated chi-square = 6.689) confirming the use of the previous model (i.e. including constant).

Model validation indicated quite good predictive performance (MAD = 1.40 and MAPE = 24.29%) (refer to Table J6.2 in Appendix J). Overall, the accuracy and consistency of the predicted values were also confirmed by Pearson's correlation test (r = 0.429; p = 0.108) and the chi-square test (calculated chi-square = 5.813 < tabulated chi-square = 16.919).

12.3.1.1 Discussions

A multiple regression model has been developed to predict and describe architects' satisfaction levels based on contractor performance. Discussion now follows.

The model identified eight significant independent variables as shown in the equation in descending order of importance. The qualification and experience of site personnel was the most important variable in the model. It is of no real surprise that the capability of site personnel influences satisfaction levels since such persons are responsible for actually carrying out the work, and will have a major impact on contractor performance. The satisfaction arising from contractor performance in general was the second most important variable. Being an attribute of the assessor, this variable suggests subjectivity is prevalent in the architects' performance assessment. That is, those architects with a high perception of contractor performance in general, are more likely to yield higher satisfaction levels.

Project overbudget was an important variable suggesting that satisfaction levels were lowered when projects are overbudget. Contractor's industrial relations (i.e. knowledge of local subcontractors / suppliers, and labour) underpin contractor performance and therefore positively influence satisfaction levels. Contractors selected through two-stage competitive tendering were found to negatively influence satisfaction levels. The significance of retail building projects suggests that architects were less satisfied when working on this type of project.

The model also indicates that architects' satisfaction levels were found to rise when contractors are paid using lump sum methods. Poor ground conditions may hamper project and contractor performance, which may therefore indirectly lower satisfaction levels.

12.3.2 Artificial Neural Network Results

An artificial neural network model was developed to predict levels of architect satisfaction based on contractor performance. Table 12.7 shows the network typologies for the first and second stage models. Based on these results of the first stage model, insensitive independent variables were pruned using sensitivity analyis. The second stage model was then used to predict satisfaction levels and is now discussed. Table 12.8 depicts the independent variables used to predict contractor satisfaction levels in descending order of importance based on the results of sensitivity analysis (for calculations, refer to Appendix K6).

The performance of the model was very good with MAD of 0.42 and MAPE of 8.37% (refer to Table L6.1 in Appendix L). Furthermore, correlation ($r = 0.969$; $p < 0.0005$) and chi-square (calculated chi-square = 3.065 < tabulated chi-square = 70.993) tests confirmed the accuracy and consistency of the model. Pearson's correlation coefficient ($r = 0.969$) and calculated chi-square (3.065) indicated that the model had been successfully trained and was able to learn the problem. Subsequent validation tests against independent variables showed that the model had average MAD of 0.98 and MAPE of 14.98% (refer to Table L6.2 in Appendix L). Correlation (r = 0.785; $p = 0.004$) and chi-square (calculated chi-square = 4.568 < tabulated chi-square = 16.919) tests confirmed that the model was valid and robust.

Table 12.7 Network typology for first and second stage models of architects' assessment of contractor performance

Network and learning parameter	First stage model	Second stage model
Type of input variables	Continuous and binary	
Type of output variables	Continuous	
Number of hidden layer	1	1
No. of PEs in input layer	59	24
No. of PEs in hidden layer	6	7
No. of PEs in output layer	1	1
Transfer function	TanhAxon	
Network connectivity	Fully connected	
Learning law	Backpropagation	
Learning algorithm	Momentum	
Step size	0.4, 0.1	0.3, 0.1
Momentum	0.6	0.6
Minimum Mean Square Error	0.0048	0.0098
No. of training epochs	109	141

Table 12.8 Total sensitivity factors (TSFs) for sensitive independent variables identified from the architects' assessment of contractor performance

Attributes	Total Sensitivity factor	Ranking
Project overbudget	1.5046	1
Method of contractor selection	1.4733	2
Type of project	0.8446	3
Type of building	0.8231	4
Procurement route	0.6765	5
Project overrun	0.6543	6
Satisfaction arising from contractor performance in general	0.5491	7
Method of contractor payment	0.3376	8
The qualification and experience of director	0.3071	9
Financial soundness of contractor firm	0.1807	10
Any previous working rel'ship with the contr's site personnel	0.0813	11
Experience with project type	0.0671	12
Severity of variations	0.0299	13

12.3.2.1 Discussions

Of the 59 independent variables, 24 (including some dummy variables) were used in the architect satisfaction model. These were aggregated to arrive at 13 variables. These variables were then ranked based on their importance (TSFs) (refer to Table 12.8). They are now discussed in the following paragraphs.

Project overbudget was the most important variable in the model. Moreover, project overrun was also an important variable and ranked sixth. This suggests that contractors should maintain their attempt to finish projects on budget and on time in order to satisfy their architects.

The method of contractor selection must be carefully considered. Due to its adversarial nature, the competitive tendering approach is likely to discourage good performance and hence lower satisfaction levels. In this case, a contractor selection methodology based on negotiation may encourage higher satisfaction levels. Procurement route was also identified as an important determinant of satisfaction. The method of contractor payment and any previous working relationship with the contractor's site personnel were ranked eighth and eleventh. Generally, these variables suggest that long-term relationships may encourage higher levels of architect satisfaction.

It is interesting to note that different types of project and building influence architect satisfaction levels. From the viewpoint of contractors and in the context of this research, these are considered beyond the control of the participants.

A respondent attribute, the satisfaction arising from contractor performance in general was an important variable (ranked seventh). This variable suggests that some degree of subjectivity is prevalent in the architects' performance assessment. That is, those architects with a high perception of contractor performance in general, are more likely to yield higher satisfaction levels.

The qualification and experience of the contractor's director was also found to influence satisfaction levels. Directors are key persons who largely determine the performance of contractors. The contractor's financial soundness was an important variable suggesting that financially sound contractors may employ more effective resources and therefore able to perform better.

The model identified experience with project type as one of the important variables. Experience may help to improve performance because contractors executing similar projects may benefit from the lessons learnt on earlier projects. Severe variations may lower architect satisfaction levels since variations demand additional resources and add to the complexity of projects.

12.3.3 Comparative Analysis

Table 12.9 compares the performance of the MR and ANN models when tested against independent data as used in the validation tests (see also Figure 12.2). The performance of the MR and ANN models was compared based on the magnitude of MAD and MAPE (i.e. in terms of accuracy and consistency) to enable the best model to be selected (as explained in section 10.2.3).

Evaluation of the models revealed that the ANN model was superior to the MR model (refer to Table 12.9).

Table 12.9 Comparison of the MR and ANN models validation

	MR	ANN
MAD	1.40	0.98
MAPE (%)	24.29	14.98
Chi-square test		
Calculated chi-square	5.813	4.568
***Tabulated* = 18.076**		
Correlation test		
Correlation coefficient	0.429	0.785
Probability	0.108	0.004
Preferred Model		✓

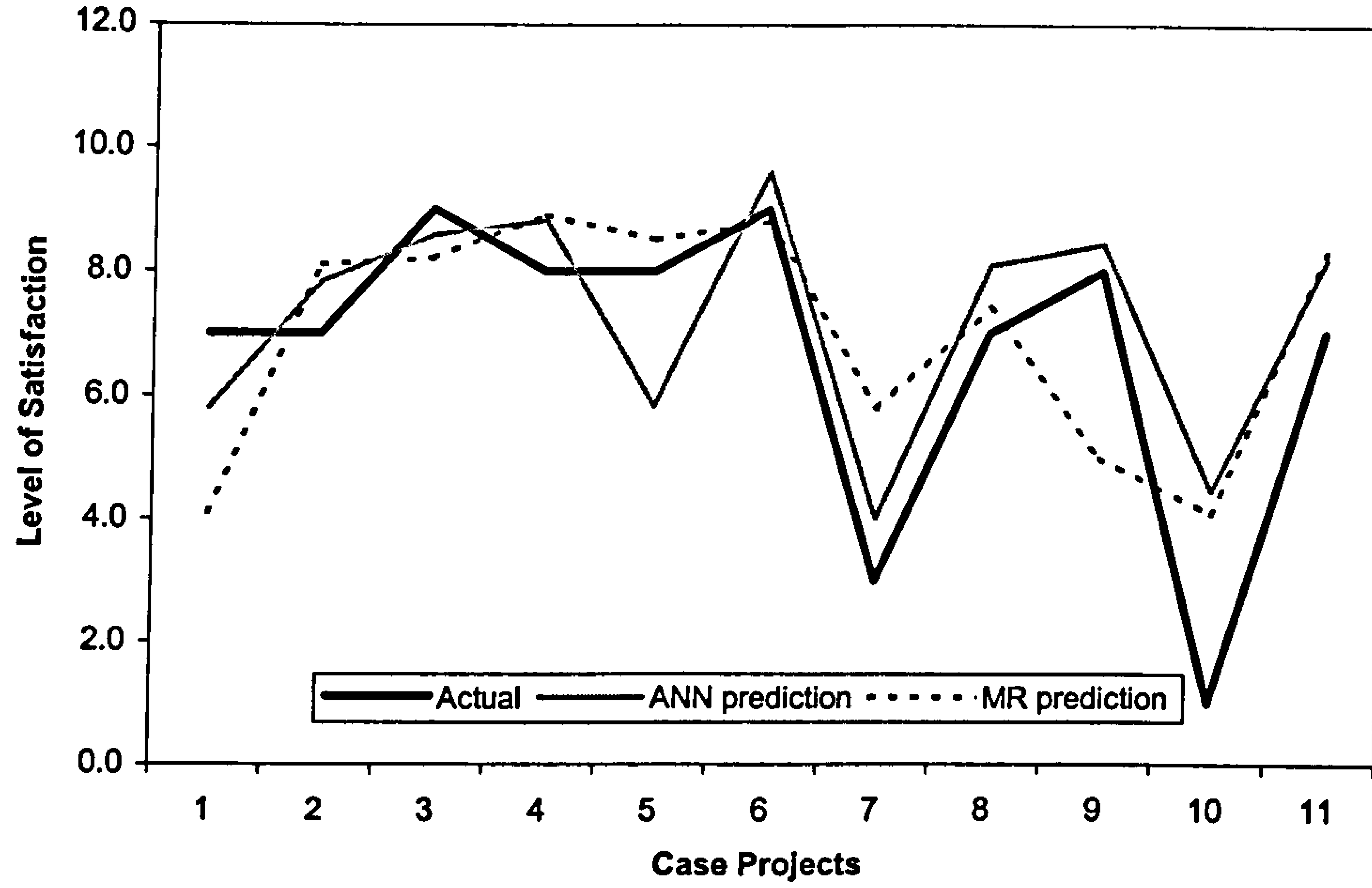


Figure 12.2 Comparison of MR and ANN models' predictions of architects' assessment of contractor performance

Some variables identified by the MR model were also identified by the ANN model. However, the levels of importance for those variables were found to differ. The ANN model required more variables than the MR model. One respondent attribute, the satisfaction arising from contractor performance in general was identified the second most important variable by the MR model and as an important variable by the ANN model highlighting the presence of subjectivity in the architects' assessment.

Observation of the most important variables identified by both techniques revealed that contractors seem to have more impact on architect satisfaction levels in the MR model. In the MR model, three out of the four most important variables (i.e. the qualification and experience of site personnel, project overbudget, the contractor's industrial relations) were considered to be within the contractors' control. Conversely, within the same levels of importance, the ANN model identified just one variable which contractors had some control (i.e. project overbudget). The ANN model emphasised the importance of project attributes such as method of contractor selection, types of project and building, and procurement route.

12.4 SUMMARY

This chapter has described the assessment of contractor performance by their clients and architects. Several models have been developed to predict and describe levels of satisfaction for clients and architects respectively, using MR and ANN techniques. Each model used the overall satisfaction measure (*totsat*) as the dependent variable and a number of attributes as the independent variables.

For the clients' assessment, the MR model identified past performance of the contractor in general and in terms of cost, time and quality as the most important independent variable. This suggests that contractors whose track records are good, are more likely to satisfy their clients. Moreover, health and safety was found to be of importance. These suggest that contractors need to consider a range of performance issues, and not necessarily focus on cost. In the ANN model, project overrun was the most important independent variable followed by any previous working relationship with the contractor's site personnel, method of contractor selection and procurement route. These suggest that long-term relationships may encourage higher client satisfaction levels. Additionally, uncontrollable project attributes, i.e. types of building and project, also significantly influence satisfaction levels. Moreover, contractors should maintain their attempt to deliver projects on time and on budget. Methods of payment to contractors should be carefully considered and negotiated before project commencement.

Overall, there are differences between variables identified by both techniques, particularly in terms of their importance and number (i.e. the ANN model used more variables than the MR model). Subsequent tests confirmed the validity of the models. In terms of accuracy and consistency, the ANN model was found to be marginally better.

For the architects' assessment, the MR model identified the qualification and experience of contractor's site personnel as the most important variable. One respondent attribute, the satisfaction arising from contractor performance in general was the second most important variable suggesting a significant level of subjectivity in the architects' performance assessment. Contractors should also maintain their attempt to deliver projects on or under budget. The ANN model identified project overbudget as the most important variable suggesting that contractors should attempt to finish projects on or under budget in order to satisfy their architects. Several of the important variables suggest that long-term relationships would encourage higher architect satisfaction levels. Some of the variables identified by the MR model were also identified by the ANN model. However, levels of importance of those variables were found to differ and the ANN model required more variables. Subsequent tests confirmed the validity of the models. In terms of accuracy and consistency, the ANN model was superior to the MR model.

Four further conclusions can be drawn from the above modelling. Firstly, according to several variables of the ANN models, long-term relationships may encourage higher satisfaction levels. Secondly, a comparison of the importance of variables in both techniques revealed that contractors seem to have more impact on satisfaction levels in the MR models. Thirdly, a comparison of the MR and ANN models in terms of accuracy and consistency for both clients' and architects' assessment, showed that the ANN models were better. Finally, one respondent attribute, the satisfaction arising from contractor performance in general was identified as an important variable suggesting that some degree of subjectivity is prevalent in the architects' performance assessment. This suggests that, in general, the architects' judgement of performance may be more subjective than clients'. However, more research is needed to confirm this aspect conclusively.

The next chapter will present a summary of the modelling work and a more detailed interpretation of the main findings presented in this and the previous two chapters. The potential practical application of the models and the implications for the construction PC will also be discussed.

Chapter 13

Summary of Models and Implications for the Construction Project Coalition

13.1 INTRODUCTION

This chapter presents a summary of the detailed modelling work undertaken, presented and described in Chapters 10, 11 and 12 respectively. The rationale for the research is presented together with the significant findings drawn from the work. Potential practical application of the models is then described. Strategic implications of the findings on the construction project coalition (PC) are finally discussed.

13.2 SUMMARY OF MODELLING SATISFACTION

In the context of the construction PC, the satisfaction of each participant is essential to harmonious working relationships which, in turn, are pre-requisites to improved project performance and successful project implementation. Based on this, the research undertook to investigate the performance and satisfaction interrelationships between main participants of the coalition. To achieve this aim, satisfaction models have been developed and validated for each participant using multiple regression (MR) and artificial neural network (ANN) techniques. Here, satisfaction is measured using the overall satisfaction scores based on one question in the questionnaire (*totsat*). Participants of the construction PC can use these models to help improve their performance leading to more successful project implementation. This will also promote the development of harmonious working relationships within the construction PC.

Significant findings resulting from the development of the satisfaction models are presented in the following for clients, architects and contractors respectively.

13.2.1 Client Performance

Figures 13.1 and 13.2 present schematic models to summarise the MR and ANN satisfaction models based on client performance. These models adopted the conceptual performance assessment model presented in Figure 1.1, as a framework. Significant variables in the models were categorised into performance (i.e. participant and project performance) and satisfaction attributes. The findings from architects' and contractors' assessments were combined. The rankings of variables' importance for each assessment are also shown in parenthesis. Variables which could be manipulated by coalition participants were highlighted in bold. This mode of presentation allows a summary of the significant variables, and hence provides a deeper understanding and more informed view of the models.

13.2.1.1 Multiple regression models

The MR models indicate that a capable client's representative helps to enhance satisfaction levels. As shown in the schematic model, the capability of the client's representative will influence client project performance and the satisfaction levels of the other coalition participants. This highlights the importance of the client's representative for both contractors and architects. Clients need to give considerable thought to the selection of their representative as this figurehead is of utmost importance to the service providers.

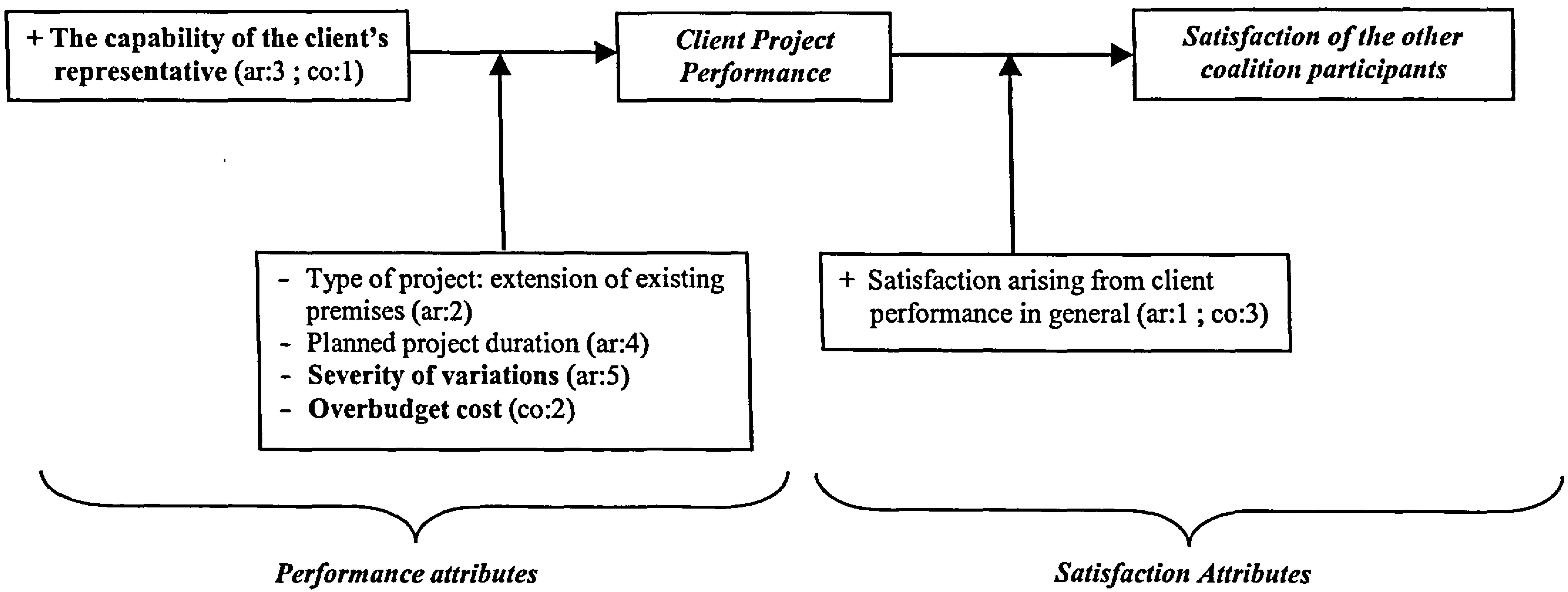


Figure 13.1 Summary of MR satisfaction models based on client performance

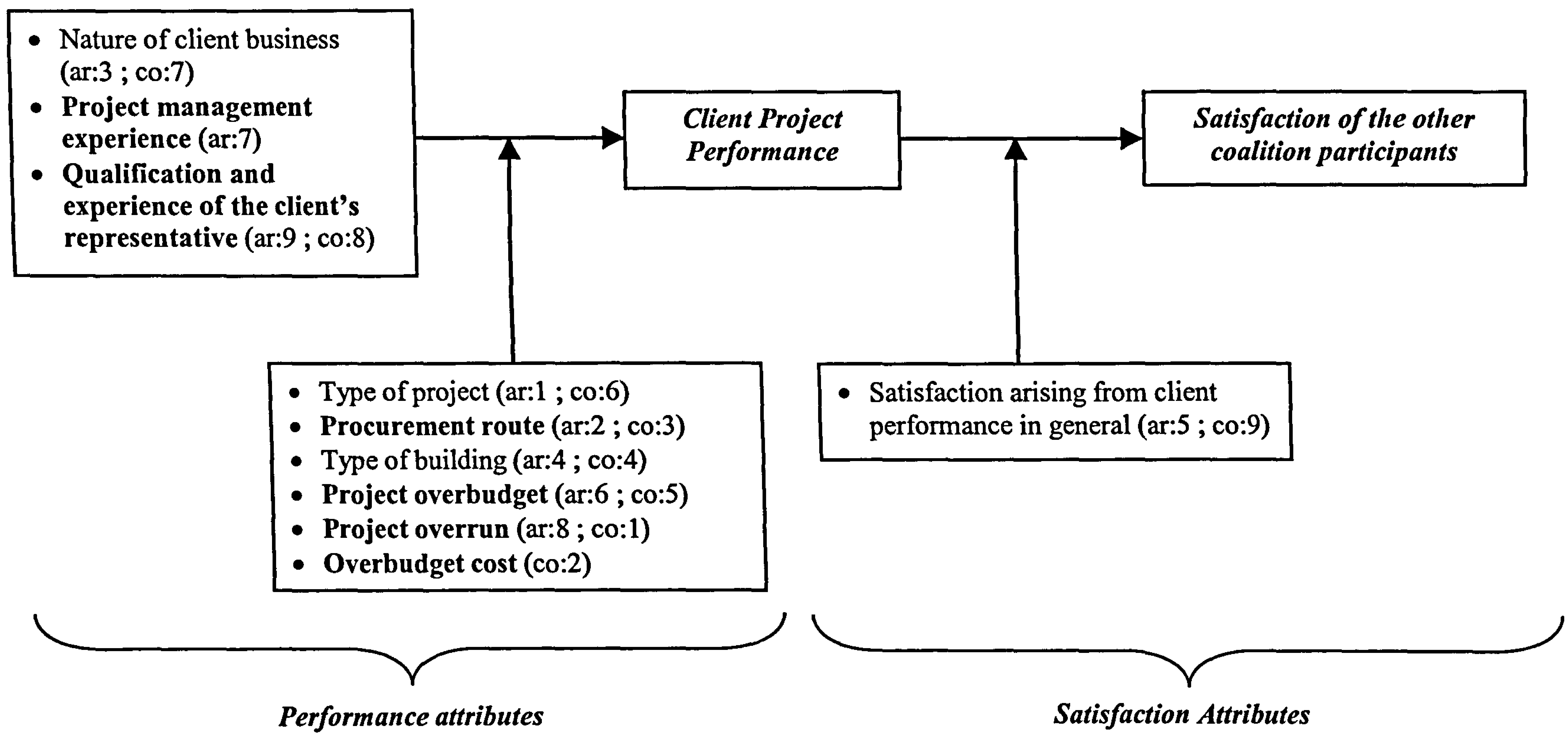


Figure 13.2 Summary of ANN satisfaction models based on client performance

Type of project (specifically extension to existing premises), planned project duration, severity of variations, and overbudget cost were found to negatively influence satisfaction levels. Here, coalition participants should attempt to avoid or reduce variations which in turn will eliminate or minimise overbudget cost. This requires a concerted approach from all participants, not merely clients. One possible reason of the negative influence of the extension projects is the uncertainty inherent within such projects, which may introduce more variations than on new-build projects. Although type of project was considered beyond the remit of the participants, this could be deemed as a warning of the possible negative influence of extension projects on satisfaction levels. The model also suggests that shorter project duration enhances satisfaction levels. This may be coincident with overbudget cost since previous analysis (refer to section 7.3.2.7) revealed a significant relationship between planned project duration and overbudget cost. This means that if a project is overbudget, overbudget cost will increase as planned duration increases. Project duration is somewhat difficult to alter since to some degree, it depends on (e.g.) the size of the project and the resources available, which have implications for the overall cost of the project.

Of interest here, was the degree of subjectivity indicated in the performance assessments, particularly the architects'. While subjectivity is difficult to change since it concerns an individuals' perception, this may be changed in the long term if, for example, clients and their representatives are willing to be involved in the construction process and to attempt to improve their performance for the betterment of project performance.

13.2.1.2 Artificial neural network models

Three client performance attributes were important, namely (i) nature of client business, (ii) project management experience and (iii) qualification and experience of the client's representative. Here, project management experience, and qualification and experience of the client's representative could be manipulated to enhance satisfaction levels. Clients with experience in project management and with capable representatives are more likely to perform better than their counterparts and hence satisfy the other participants of the PC. The nature of client business is somewhat difficult to influence as service providers are not often in a position to select their clients.

The ANN models identified the importance of selecting an appropriate procurement route (ranked second and third) and the need to deliver projects on time and to budget for both contractors and architects. Presently, the industry is moving towards long-term, relationship-based procurement routes, such as partnering and strategic alliances which may have advantages over traditional competitive tendering routes. Previous analysis of the relationship between procurement route and time and cost performance[1] (refer to section 7.3.2.2, Tables 7.25 and 7.28) revealed that partnering was superior than the other routes. Here, the use of relationship-based routes will reduce the probability of overrun and/or overbudget and therefore enhance performance and satisfaction levels. Type of project and building were also important variables, however they are considered uncontrollable variables which could not be altered. Interestingly, in terms of time performance, retail building projects where partnering was extensively used (refer to Table 7.22), were better than the other types of building projects (refer to Table 7.49).

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[1] It is not the intention to equalize levels of satisfaction and time and cost performance (i.e. to relate levels of satisfaction and time and cost performance). However, time and cost performance provide objective measures of performance which may influence and/or relate to satisfaction levels. (This also applies to sections 13.2.2.2, 13.2.3.1 and 13.2.3.2 in this chapter).

The satisfaction arising from client performance in general was a significant variable in both architects' and contractors' assessments. This suggests the presence of subjectivity in performance assessment. Here, the architects' assessments may be more subjective than contractors' since the architect's model identified this variable as being more important.

13.2.1.3 Comparison of the models

Overall, there are several differences between the models, particularly in terms of the number and importance of variables. The performance of the client appears to have more impact on satisfaction levels in the MR models. In contrast, the ANN models tended to highlight the importance of project specific variables such as project overrun / overbudget, type of project and building, and procurement route. Finally, one respondent attribute was identified as an important variable suggesting that some degree of subjectivity is prevalent in both the contractors' and architects' assessment. This was particularly evident in the architects' assessment suggesting that, in general, contractors' judgement of performance may be more objective than architects'. However, more research is needed to confirm this aspect conclusively.

Validation tests showed that these MR and ANN models were valid and robust. However, in comparing the MR and ANN models for accuracy and consistency, the results were inconsistent. Generally, while the ANN model seemed more appropriate for the architects' assessment, it was the MR model which better reflected the contractors' assessment.

13.2.2 Architect Performance

Figures 13.3 and 13.4 present schematic models to summarise MR and ANN satisfaction models based on architect performance. The method of presentation is as described in section 13.2.1. Discussion now follows.

13.2.2.1 Multiple regression models

The MR models identified several variables which all but one could be manipulated by the PC participants to enhance satisfaction levels. The qualification and experience of the project architect was the most important variable in both clients' and contractors' assessments, suggesting that capable project architects are essential for high levels of satisfaction. This highlights the crucial role that the project architect plays in the coalition. The quality of previous working relationships with other participants was also significant suggesting that harmonious working relationship among participants enhances satisfaction levels. The architect's reputation in terms of adherence to schedule and budget, and design quality was found to positively influence satisfaction levels suggesting that architects of high repute are most likely to satisfy the other participants. It is surprising that relevant experience in the type of project negatively influences satisfaction levels. More research is needed to investigate this aspect.

Several controllable project attributes were found to negatively influence satisfaction levels, namely (i) severity of variations, (ii) project overbudget, (iii) overbudget cost, and (iv) project overrun. These suggest that participants should attempt to reduce variations, deliver projects on or before programme and to or under budget. The extent to which the project is constrained by weather conditions was found to positively influence satisfaction levels. Although this variable is considered uncontrollable, its positive influence is quite

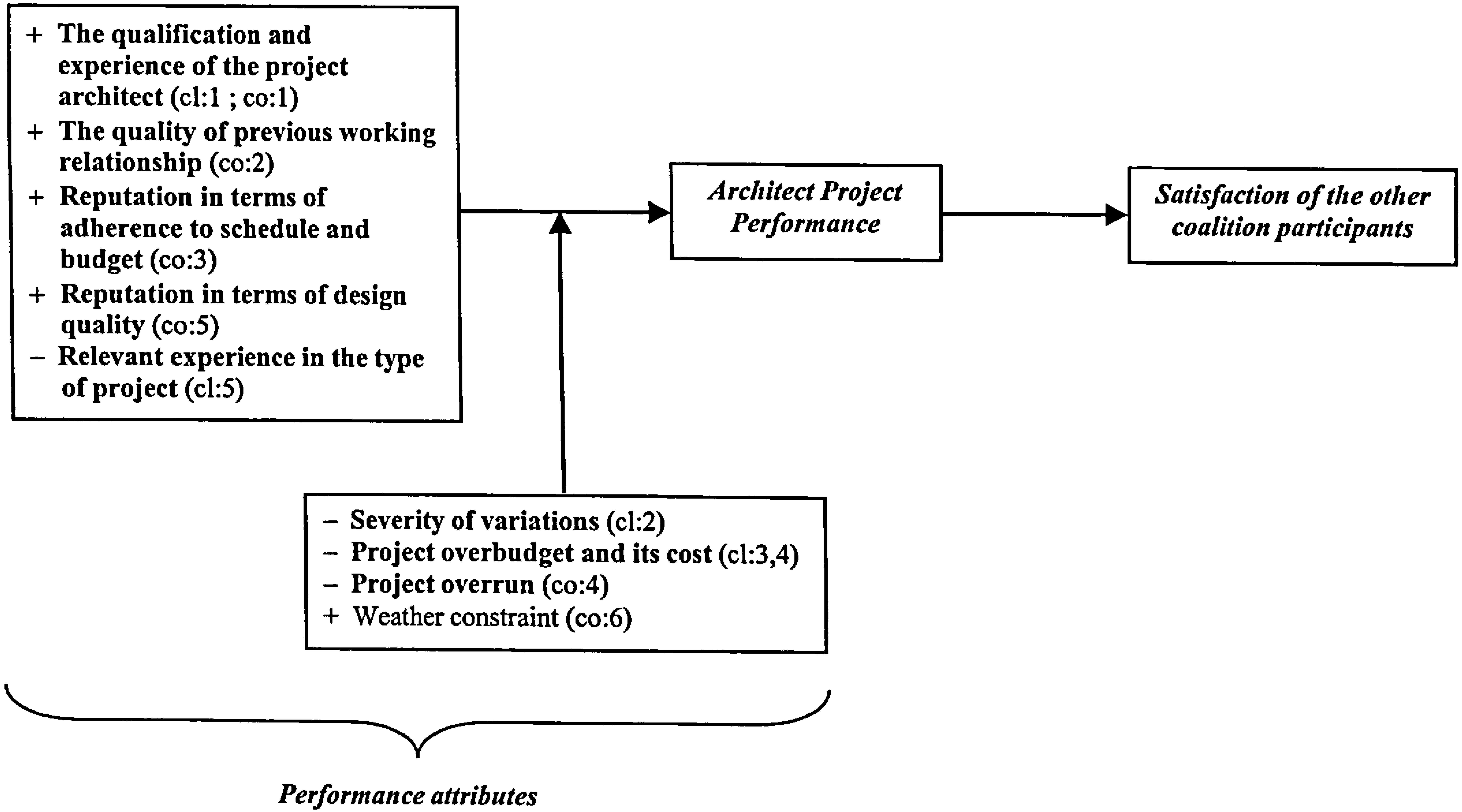

Figure 13.3 Summary of MR satisfaction models based on architect performance

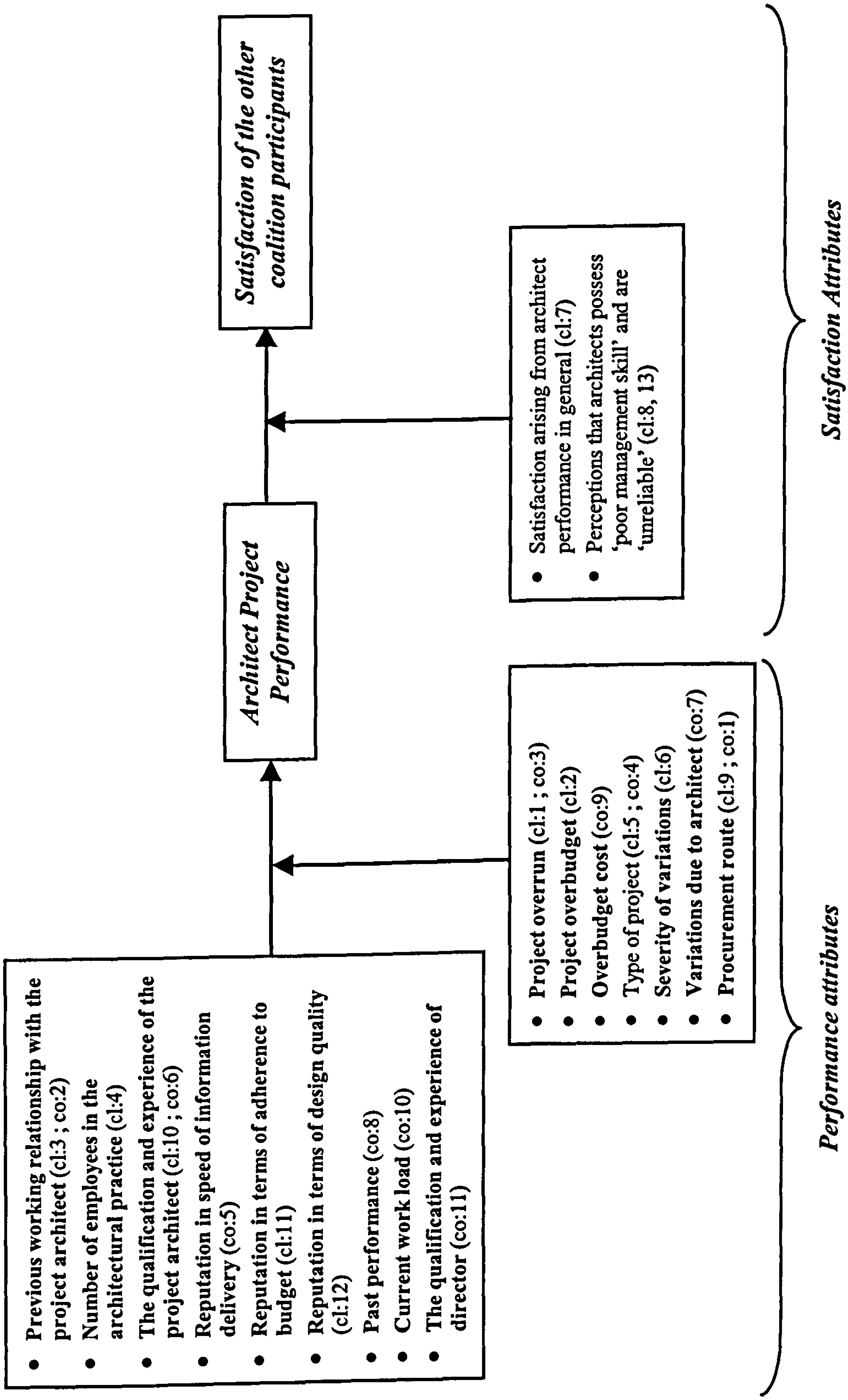

Figure 13.4 Summary of ANN satisfaction models based on architect performance

surprising. Perhaps, familiarity and experience of UK weather help to minimise its impacts on project implementation.

13.2.2.2 Artificial neural network models

Nine architect performance attributes were identified as important variables and considered controllable by the PC participants. The models suggest that previous working relationships with the project architect may enhance satisfaction levels. The size of the architectural practice (measured by number of employees) was found to influence satisfaction. The model identified the qualification and experience of the project architect and director as important variables highlighting the important roles played by these key persons in the project coalition. The models also identified that the track record (reputation and past performance) of the architect influence the satisfaction of the other coalition participants. Current work load should also be considered when selecting an architectural practice.

Seven project attributes were important and considered controllable by the PC participants, with type of project as the exception. Project overrun and overbudget were important variables indicating that participants should attempt to complete projects on time and schedule to acquire higher satisfaction levels. Moreover, participants should also attempt to reduce variations. Procurement route was the most important variable as identified by contractors. This may suggest that relationships-based procurement routes such as partnering and strategic alliances may have advantages over traditional competitive tendering. Previous findings (refer to section 7.3.2.2, Tables 7.25 and 7.28) also support the use of partnering due to its superiority in time and cost performance.

Three satisfaction attributes were significant in the client model, namely the satisfaction arising from architect performance in general and perceptions that architects possess 'poor management skills' and are 'unreliable'. These suggest some degree of subjectivity is prevalent in the clients' assessment of architect performance.

13.2.2.3 Comparison of the models

Similar differences were found between the two modelling techniques as for the models based on client performance (refer to section 13.2.1.3). Architects appeared to have more impact on the satisfaction levels of clients and contractors in the MR models. Only in the ANN client satisfaction model were levels of subjectivity found to be relatively low. Of interest here, the contractors' assessment did not seem to suggest any subjectivity. That is, no satisfaction attributes were identified in the contractors' assessment.

Validation tests showed that the models were valid and robust. The ANN models were more accurate for both clients' and contractors' assessments.

13.2.3 Contractor Performance

Figures 13.5 and 13.6 present schematic models to summarise the MR and ANN satisfaction models based on contractor performance. The method of presentation is as described in section 13.2.1. Discussion now follows.

13.2.3.1 Multiple regression models

The MR models identified six contractor performance attributes as important variables. These variables could be manipulated by the PC participants to enhance satisfaction levels. Past performance and capability of site personnel were identified as the most important

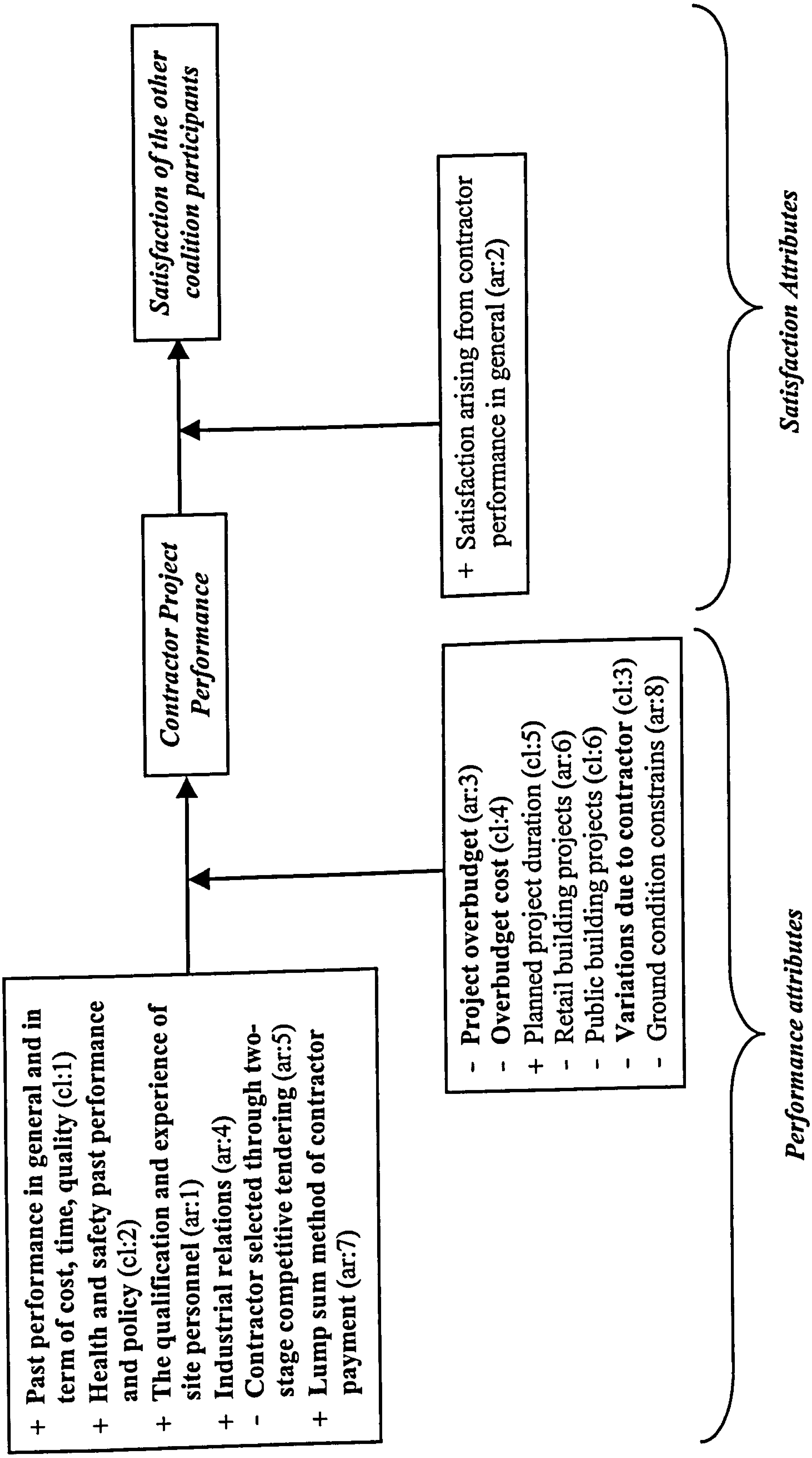

Figure 13.5 Summary of MR satisfaction models based on contractor performance

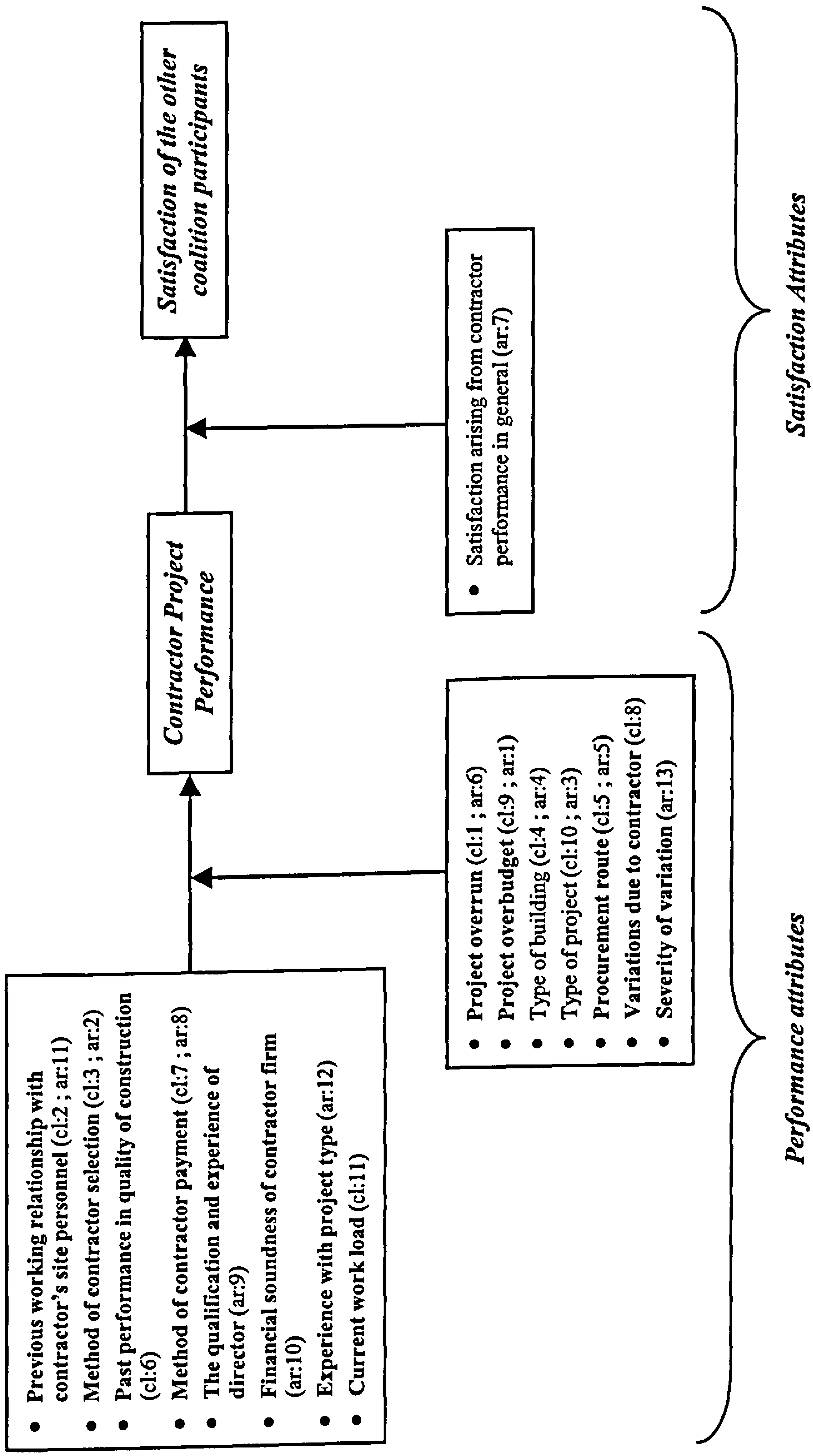

Figure 13.6 Summary of ANN satisfaction models based on contractor performance

variables by clients and architects respectively. Moreover, health and safety past performance and policy was the second most important variable in the clients' assessment. These suggest that contractors whose past performance is good, are more likely to satisfy their clients. Furthermore, capable site personnel are essential for enhanced satisfaction levels. Site personnel are responsible for actually carrying out the work, and will have a major impact on contractor performance and hence satisfaction levels. Contractor's industrial relations (i.e. knowledge of local subcontractors / suppliers, and labour) underpin contractor performance and therefore positively influence satisfaction levels. Contractors selected through two-stage competitive tendering were found to negatively influence satisfaction levels. Previous analysis (refer to section 7.3.2.3, Tables 7.33 and 7.36) indicated mediocre time and cost performance of this competitive method. The analysis suggests that contractors appointed by negotiation provide a higher probability of better time and cost performance. The model also indicates that satisfaction levels were found to rise when contractors are paid using the lump sum method.

The models identified three controllable and four uncontrollable project attributes. It is not really surprising that satisfaction levels are low when projects are completed overbudget and incur many variations. Therefore, contractors should attempt to reduce variations and keep the project to budget if they are to satisfy the other coalition participants. It is interesting to note that larger projects (i.e. longer planned project duration) were found to raise satisfaction levels. This may be connected to the prestige associated with such projects, and the need to involve well resourced and experienced contractors whose performance may be superior to smaller firms. Clients (i.e. public clients) and architects were found less satisfied on public and retail building projects respectively. Perhaps, for the former, this might be connected to the poor time performance associated with public building projects (refer to section 7.3.2.6, Table 7.49), and for the latter, this might be connected to the lack of design flair and aesthetics in retail projects (i.e. less prestigious projects in terms of satisfying architect's ego as a creative designer). Poor ground conditions may hamper project and contractor performance, which may therefore indirectly lower satisfaction levels.

The satisfaction arising from contractor performance in general was the second most important variable in the architect assessment. This variable suggests subjectivity is prevalent in the architects' performance assessment. That is, those architects with a high perception of contractor performance in general, are more likely to yield higher satisfaction levels.

13.2.3.2 Artificial neural network models

The ANN models identified eight contractor performance attributes as important variables. All could be manipulated by the PC participants to enhance satisfaction levels. Well-established working relationships with the contractor's site personnel may produce higher satisfaction levels. Further, the procurement of the contractor must be carefully considered. Due to its adversarial nature, the competitive tendering approach is likely to discourage good performance and hence lower satisfaction levels. In this case, a methodology based on negotiation would encourage higher satisfaction levels. Negotiation was most likely to derive better time and cost performance than other methods (refer to section 7.3.2.3, Tables 7.33 and 7.36). These two variables suggest that long-term relationships would encourage higher satisfaction levels. In addition to these, the method of contractor payment should be carefully considered and negotiated before project commencement as this determines risk allocation and thereby influences performance and working relationships. Past performance in quality of construction suggests contractors should also pay more attention to their quality control if they are to satisfy the other coalition participants. The qualification and experience of the director was also found to influence satisfaction levels. Directors of contractors are key persons who largely determine the performance of the contractors. The contractor's financial soundness was an important variable suggesting that financially sound contractors may employ more effective resources and therefore are able to perform better. Experience with project type may help to improve performance because contractors executing similar project may develop a familiarity with the way the difficulties involved. The current work load of contractors should also be considered before appointment. Although an excessive work load can be detrimental to performance, a steady and continuous flow of work may enhance contractor performance through the opportunity to gain more experience, sustain the business financially, and to employ better and adequate resources.

The models identified five controllable and two uncontrollable attributes as important variables. Project overrun and overbudget were the most important variables identified by clients and architects respectively. This suggests that to deliver projects on programme and to budget is crucial for higher satisfaction levels. In addition to these, participants should attempt to reduce variations. The type of procurement route was also found to influence satisfaction. Type of project and building were considered uncontrollable variables which in the context of this research, can not be altered.

The architects' assessment again indicated some degree of subjectivity due to one satisfaction attribute, the satisfaction arising from contractor performance in general, being an important variable.

13.2.3.3 Comparison of the models

Similar differences were found between the two modelling techniques as for the models based on client performance (refer to section 13.2.1.3). Contractors seemed to have more direct impact on the satisfaction levels of clients and architects in the MR models. The ANN models emphasised the importance of project attributes such as project overrun and overbudget. While architects exhibited some level of subjectivity in their performance assessment, clients did not. That is, no important satisfaction attributes were identified in the clients' assessment.

Validation tests showed that the models were valid and robust. The ANN models were more accurate for both clients' and architects' assessments.

13.2.4 Summary of Models Comparison

A comparison of the models revealed that the ANN models tended to highlight the importance of qualitative as opposed to quantitative variables. Qualitative variables were represented by binary dummy variables in the modelling process. These included several variables relating to the procurement route highlighting the importance of such strategic issues. These qualitative variables also underlined the 'softer' issues such as previous (long-term) relationships among participants. Conversely, the MR models tended to highlight quantitative variables as being more important represented mostly by performance and respondent attributes. That is, the MR models appeared to emphasise the interaction and dependency between the performance levels of the participants.

Attributes of the respondents (i.e. assessor) were identified as useful predictors indicating that some degree of subjectivity is prevalent in performance assessment, especially on behalf of architects. In contrast, the contractors' assessment was considered the most objective.

A comparison of the MR and ANN models in term of accuracy and consistency revealed that ANN models were generally better than the MR models. The ANN models were better in five performance assessment cases as shown in Table 13.1, although this difference was only marginal.

Table 13.1 More accurate and consistent model for each performance assessment

Respondent	Performance Assessment		
	Client	Architect	Contractor
Client	-	ANN	ANN
Architect	ANN	-	ANN
Contractor	MR	ANN	-

13.3 POTENTIAL PRACTICAL APPLICATION OF THE MODELS

The validity and reliability of the MR and ANN models developed have been demonstrated. In their present form, the models could be used to predict satisfaction levels by participants (as either an assessor or a performer) of the PC at the earliest possible stage in the project life cycle. While, as an assessor, participants could predict their satisfaction levels based on the performance of the other participants (e.g. clients to assess contractor performance), as a performer, participants could predict the satisfaction levels of the other participants based on their own performance (e.g. client performance to be assessed by contractors). The models are best utilised in the earlier stages of the project when corrective actions suggested by the models are more likely to influence final project outcomes. For the MR models, predicted satisfaction levels would be determined through simple mathematical calculation. For the ANN models, predicted satisfaction levels would be produced by utilising the trained networks (in NeuroSolutions software as used in this research) to 'transform' the input (i.e. attributes) into the output.

Since in terms of accuracy and consistency, there were only marginal differences between the models developed by both techniques, the MR models may be preferred. The reasons are two fold. Firstly, the MR models used less variables than the ANN models and hence may be considered simpler, and second, the MR models can be applied by using relatively straight forward mathematical calculations rather than the complex equations used in the ANN models. That is, in their present form, the MR models may be more practical and easier to adopt by practitioners.

Notwithstanding this, the ANN models could have advantages in terms of their future development. The models could be enhanced by linking the statistical models to an interactive / more user-friendly software, possibly in the form of an expert system. This expert system would ask users to enter the relevant performance and satisfaction attributes necessary to develop the models. Then, it would 'transform' these attributes into input variables for the models. The outputs, i.e. satisfaction levels, could be computed and shown to the users. A further advance to this expert system would be to recommend possible actions required aimed at enhancing satisfaction levels.

The expert system could be used by performer(s) (e.g. contractors) and / or assessor(s) (e.g. clients). For the performer, the results could be useful as an introspection tool aimed at improving performance as well as enhancing (e.g. client) satisfaction levels. For the assessor, the results could be used to select the 'best', e.g. contractor, for a particular project. The results would also suggest what project environment (i.e. project attributes) is suitable to execute a particular project. The expert system itself would also serve as a project simulation tool, which could be used at any stage within the project life-cycle so that corrective actions could be taken to remedy problems. Benefits would be maximised if this tool could be used in initial project meetings among PC participants where problems could be identified early on, allowing them to be addressed (and hopefully resolved) before conflicts develop. For these to be effective, all participants must be prepared to be open, honest and exhibit a willingness to be criticised, constructively. This tool would be specifically beneficial for partnering or strategic alliances because it would stimulate communication and cooperation among participants involved.

13.4 STRATEGIC IMPLICATIONS FOR THE CONSTRUCTION PROJECT COALITION

The satisfaction models identified the key determinants of satisfaction for each participant. The major determinants have been discussed in the previous section (section 13.2). Although some determinants are beyond the control of participants (e.g. inclement weather) and may be due to for example subjectivity, many are within the control of participants. These determinants will enhance satisfaction levels if they are effectively addressed, particularly in the early stages of project development. Participants should focus on these determinants in order to enhance satisfaction levels and ultimately achieve better participant and project performance. The following paragraphs describe the strategic implications of the research findings for the construction project coalition.

Suppose an experienced commercial client is commissioning a £10 million office building. The client has a property department dealing with all construction works. The client needs to appoint a project manager who will be a representative responsible for project execution and a contact point for the service providers to the client organisation. Given this crucial role, this representative should be carefully selected. The client's representative should demonstrate adequate technical skills to be able to understand the scope, complexity and technology involved, as well as adequate people-management skills to foster client focus in the production of the project (Walker, 1994; 1995; 1998). Specifically, Walker (1998) suggested that client's representatives should be able to retain high levels of confidence from their construction and design teams. This is because "they:

- are sophisticated in terms of knowing what is involved with the project, its scope and complexity, and are able to offer and accept advice about both the design and construction;
- have good communication skills;
- have good team-building and interpersonal skills; and
- clearly communicate the priorities of the client's objectives" (Walker, 1998).

With these skills, the client's representative should also be able to initiate the support and proactiveness of all participants. This, therefore, will improve client performance which in turn will enable the other participants to perform better.

Next step would be to appoint service providers, that is an architect and contractor[2]. The architect should have a good track record and a high reputation in terms of speed of

[2] For the purpose of this discussion, service providers are limited to core project coalition participants, i.e. architect and contractor for reasons described in section 1.1, p.3.

information delivery, adherence to schedule and budget, and design quality. In addition to these, current work load and number of employees of the architectural practice should also be considered. Ideally, a steady and optimum work load and adequate resources to cope with this work load should be favourable. Experience in similar projects should also be considered favourably. The director (i.e. partner) of the architectural practice should have relevant qualifications and experience to deal with such projects. The project architect should be carefully selected. In this case, clients may influence such an appointment. In addition to possessing excellent architectural skills, project architects should also have appropriate technical skills and be willing to cooperate with other participants, and so help them to perform more effectively. Therefore, good project architects should possess 'hard' and 'soft' skills (Ling *et al.*, 1999; 2000). 'Hard' skills are general mental ability, job knowledge, task proficiency, and job experience (Schmidt *et al.*, 1986 cited in Ling *et al.*, 2000). 'Soft' skills include conscientiousness, initiative, social skills, controllability, and commitment (Borman and Motowidlo, 1993 cited in Ling *et al.*, 2000). These 'soft' skills are important to enhance customer satisfaction and therefore, architects should acquire and inculcate these skills (Ling *et al.*, 1999; 2000). In the construction PC, these skills enhance cooperation and harmonious working relationships which facilitate improved participant and project performance.

It is worth emphasising that the capability of the client's representative and project architect both have a highly significant impact on satisfaction levels. They represent the primary points of contact and are key persons in the relationships within the project coalition, enabling participants to 'tangibly' performance better. Furthermore, such contacts ease communication and decision making at the point where physical construction takes place.

Generally, the contractor should have a good track record of past performance but also in terms of cost, time, quality and health and safety. In addition to these, the contractor should have adequate financial resources and good industrial relations (i.e. knowledge of local suppliers and labour) which are to some extent, related to current work load. Contractors with a steady and continuous flow of work and with experience of similar projects are more likely to perform effectively. In addition to these, the method of contractor payment should be carefully considered, negotiated and agreed before project commencement.

Most importantly in the selection of the architect and contractor, the client should consider any previous relationships between the participants. That is, participants having good previous working relationships (including those at the site personnel level) are more likely to produce better project performance and ultimately higher satisfaction levels. Based on interviews with construction practitioners, Nicolini (2002) found that retaining the same participants throughout a project and allowing for repeat work of the same participants across several projects helps to capitalize on time, effort and resources invested. This is connected with the selection of the procurement route. Results of the modelling, particularly the ANN models suggest that the selection of an appropriate procurement route is crucial to participants' satisfaction. Clients, as project promoters, are responsible for determining an appropriate procurement route (e.g. Jawahar-Nesan and Price, 1997; Tookey *et al.*, 2001), which ultimately will influence their own satisfaction levels. Here, long-term, relationship-based procurement routes, such as partnering and strategic alliances may have advantages over traditional competitive tendering routes. Winch (1989) believed that competitive tendering is a source of project (specifically, contracting) uncertainty which has the greatest impact. This leads to opportunistic behaviour being shown by the participants of the PC, such as introducing variations and claims in order to recover losses due to extremely low bids. Ultimately, this results in poor project performance, adversarialism and dissatisfaction.

Partnering has been claimed to enhance project performance by improving relationships among PC participants, resulting in improved management of risk, greater financial control (fewer claims and cost overruns), timely completion, increased job satisfaction and camaraderie among participants, and reduced litigation (ASCE, 2000). Partnering is not a technique which establishes rules, regulations, documentation and procedures but is a proactive approach to the management of business relationships (Matthews *et al.*, 2000). All these ultimately enhance the satisfaction levels of each participant, particularly because the benefits derived impact on all involved (Baden Hellard, 1996). It is worth noting that the required 'soft' skills for both the client's representative and the project architect (as described above) concur with the management skills considered essential for successful partnering (Cheng *et al.*, 2000). This suggests that if participants possess the 'soft' skills (in addition to the 'hard' skills), they are more likely to make a success of long-term relationship based procurement routes, and hence greatly enhance satisfaction.

Once participants have been selected, Nicolini (2002) recommended that an initial professionally facilitated workshop be arranged to give the participants the right start and enhance the likelihood of developing good 'project chemistry'. Good 'project chemistry' captures a quality of the interaction between participants on a project, i.e. an intangible characteristic of coalition participants interaction that many have posited as the basis of successful partnering (Nicolini, 2002). Although a climate of collaboration should be achieved throughout all project participants, the initial focus should be on the small core participants including senior members of the participating organisations. The climate of collaboration then propagates to other members and those participating at later stages (Nicolini, 2002).

Once the project commences, all participants should attempt to avoid or reduce variations and to keep the project on programme and to budget. This requires a concerted approach from all participants involved which will be underpinned by the use of partnering and strategic alliances. Good and open communication, and collaboration between participants should be maintained throughout the course of the project. This in turn will result in the maintenance of team trust and cohesiveness. Friendliness is an important aspect but not a sufficient condition for harmonious working relationships (i.e. good 'project chemistry') since it does not imply respect or capacity to listen and disagree, and a willingness to be criticised constructively (Nicolini, 2002). Therefore, it is important that regular meetings be held, perhaps once a month (once a week at site level) or more frequent, particularly to address performance issues. Here, feedback on performance should be deemed as constructive comments. The performance criteria of each participant which were compiled in this research (refer to Chapter 5) may be useful in providing an indication of strengths and weaknesses of each participant. That is, to identify problems before they develop into conflicts. The 'assessment' requires a team effort including all coalition participants to pursue continuous improvement and satisfactory performance. Hence, the 'assessment' would be a mutual process in a real sense, supporting the development of long-term relationships and high satisfaction levels.

13.5 SUMMARY

Traditionally, the main participants of the construction project coalition (PC) are *the client, the architect*, and *the contractor*. Here, each participant needs to be satisfied with the performance of the other participants if harmonious working relationships are to be sustained, which, in turn, are pre-requisite to improved project performance and successful project implementation. Hence, there is a need to investigate the performance and satisfaction interrelationships between main participants of the coalition and their determinants of satisfaction. To achieve this aim, models of satisfaction for each participant have been developed and validated using multiple regression (MR) and artificial neural network (ANN) techniques.

Results suggest that the client's representative is key to determining the satisfaction of the service providers (architects and contractors). Similarly, the project architect is key to the clients' and contractors' satisfaction levels. For clients and architects to be satisfied, selecting contractors with an excellent record of past performance is essential. Most importantly, the selection of an appropriate procurement route is also crucial. Here, long-term, relationship-based procurement routes, such as partnering and strategic alliances may have advantages over traditional competitive tendering routes. Although some degree of subjectivity is apparent, satisfaction levels can be enhanced through the effective performance of all participants and adopting relationship-based procurement routes. An example of how the models might be applied in industry has been described highlighting the need for practicality and possible future development. The strategic implications of the research findings for the construction project coalition have also been discussed.

In sum, while the satisfaction levels of each participant can not be maximised through one such (e.g. Ph.D.) research, the models developed improve understanding of the determinants of satisfaction, and ultimately enable each participant to enhance their own performance and satisfaction levels by focusing on certain aspects (i.e. determinants / attributes) in need of improvement and/or attention.

Chapter 14

Conclusions of the Research Work

14.1 INTRODUCTION

This chapter concludes the research work undertaken. First, a review of the research objectives and their achievement is discussed in detail. Then, limitations of the research are described, before finally, recommendations for possible further research are provided.

14.2 REVIEW OF RESEARCH OBJECTIVES

To achieve the research aim, that is to develop models of satisfaction for participants of the PC, several principal research objectives have been successfully accomplished. A review of the research objectives as described in Chapter 1, section 1.2 is presented here including:

i) investigation of the nature of interrelationships between main participants of the PC based on an in-depth literature review, encompassing the fields of construction, organisational sociology, psychology and behaviour;

ii) identification of the determinants of satisfaction, which include participant performance attributes, project attributes, and assessor attributes;

iii) identification of performance criteria for each participant in the context of their satisfaction / dissatisfaction;

iv) development of principal data collection instruments, i.e. PC questionnaires;

v) distribution of UK-wide questionnaire surveys of clients, architects and contractors;

vi) preliminary data analysis for identifying potentially statistically significant independent variables;

vii) exploration on the characteristics of the case projects involved in this research using descriptive and bi-variate analyses;

viii) preparation of data acquired from the questionnaire surveys for modelling;

ix) determination of a legitimate measure of satisfaction to be used as a dependent variable in the models;

x) assessment of the validity and reliability of satisfaction measures for use as dependent variables in the development of models;

xi) development of models of satisfaction for each participant using appropriate techniques;

xii) validation of the models through rigorous testing using data not used in the modelling process; and

xiii) broad dissemination of the research findings for the benefit of industry, academia and the research community.

14.2.1 Investigation of the Nature of Interrelationships between Main Participants of the PC

To provide a solid foundation for the research, an investigation of the nature of interrelationships between main participants of the PC was conducted based on a review of literature in the fields of psychology, organisational behaviour and sociology as presented in Chapter 2. This further explained and described the interrelationships between clients, architects and contractors in the context of the construction PC (i.e. a temporary organisation with many participating organisations). Finally, a conceptual model of performance and satisfaction was presented representing the foundation upon which this research was to be based.

14.2.2 Identification of the Determinants of Satisfaction

As hypothesised in Chapter 1, section 1.3, performance and satisfaction attributes were thought to be fundamental to the satisfaction process (i.e. to influence satisfaction judgements), and therefore key to the intended modelling work. Performance attributes including participant and project performance attributes, were identified from a thorough review of literature in the performance domain. These were also supported by the results of interviews with expert practitioners. The development of satisfaction attributes was first based on a review of the antecedents of satisfaction. These attributes were developed based on the author's interpretation, reasoning and judgement, and subsequently verified during interviews and through a pilot survey of practitioners. This process yielded a set of performance and satisfaction attributes (i.e. determinants of satisfaction) to be included in the questionnaires.

14.2.3 Identification of Performance Criteria for Each Participant

The identification of performance criteria was mainly achieved through interviews with expert practitioners including 12 clients, 19 architects and 9 contractors representing top UK participants. This process involved asking the interviewees what criteria they normally used to assess the performance of the other two participants in the PC. The interviews were tape-recorded, transcribed and analysed using the content analysis technique. This process yielded three sets of performance criteria which were then included in the questionnaires.

14.2.4 Development of Principal Data Collection Instruments

A structured survey was selected as the most appropriate data collection technique, principally because this would provide the required volume of data for analysis purposes.

The main participants of the project coalition (i.e. clients, architects and contractors) were targeted as part of the survey. Each respondent (e.g. client) was asked to assess the performance of the other two participants (e.g. architect and contractor) on a particular case project. This approach provided six performance assessment cases in total (i.e. two for each type of participant). Three questionnaires were developed based on the attributes and criteria identified.

14.2.5 Distribution of UK-wide Questionnaire Surveys of Clients, Architects and Contractors

Following the implementation of a pilot survey, the first stage of a major survey of clients, contractors and architects was undertaken. Preliminary data analysis of the first stage survey allowed the questionnaires to be shortened and then used in the second stage of the survey.

14.2.6 Preliminary Data Analysis for Identifying Potentially Statistically Significant Independent Variables

The purposes of this analysis were two fold: first, to obtain a more manageable (i.e. smaller) number of variables which had the potential to be important variables and so allow efficient and effective analysis to be conducted; and second, to reduce the length of the questionnaires to be used in the second stage survey in order to obtain the response required to allow further meaningful statistical analysis. Based on data obtained from the pilot and first stage surveys, satisfaction measures (as dependent variables) were derived using the principal components analysis technique. Bi-variate correlation analysis was used to correlate attributes (i.e. independent variables) and satisfaction measures (i.e. dependent variables). The attributes which had significant correlation (i.e. equal to or better than the 5% confidence level), were selected for inclusion in the revised questionnaires and used in the second stage survey.

14.2.7 Exploration on the Characteristics of the Case Projects

Significant project attributes were subjected to descriptive and bi-variate analyses to explore the characteristics of the case projects. The aim was to acquire information that could be useful for subsequent interpretation of the models developed. First, the characteristics of the case projects were presented and discussed. Several interesting findings were revealed such as the popularity of the traditional competitive tendering route and high percentages of project overrun and/or overbudget. Then, various bi-variate tests including chi-square, Kruskal-Wallis, Mann-Whitney and Pearson's correlation tests, were applied to investigate the interrelationships between variables. Further interesting findings were revealed such as the outstanding performance of partnering and negotiation in terms of time and cost.

14.2.8 Preparation of Data Acquired from the Questionnaire Surveys for Modelling

The data preparation for modelling involved methods used to deal with missing values, systematic treatments of independent variables including multicollinearity and binary variables transformation. Missing values in the data (i.e. dependent and independent variables) were investigated and imputation methods to deal with such values were explored and selected, resulting in a complete set of data. The optimum solution for multicollinearity was found to be combining independent variables that were highly interrelated into a single indicator. To be included in the models, several nominal data, for example procurement route, type of project had to be transformed into binary dummy variables in the form of 0 or 1 ('no' or 'yes').

14.2.9 Determination of a Legitimate Satisfaction Measure

Two possible measures of satisfaction were included in the questionnaire. First, respondents were asked to gauge their satisfaction levels against a wide range of performance criteria, and secondly against one overall measure of satisfaction (*totsat*). Prior to modelling work, a crucial question was encountered: That is, which measure is the most legitimate for modelling purposes? That is, whether to use multiple or a singular measure of satisfaction as the dependent variable.

To answer this question, the principal components analysis (PCA) was applied to develop four to five dimensions for each performance assessment case (e.g. clients' assessment based on architect performance). Each dimension contained several performance criteria which were found to represent a similar theoretical concept. The mean scores of the performance criteria for each dimension represented the participants' satisfaction levels (i.e. satisfaction measures). Additionally, correlation analysis was used to investigate the interrelationships between dimensions and *totsat*. Based on the results of the PCA and the correlation analysis, it was finally decided to employ overall satisfaction (*totsat*) as the principal measure of satisfaction.

14.2.10 Assessment of the Validity and Reliability of the Satisfaction Measure

The satisfaction measure was then tested for its validity and reliability. Validity and reliability are important because they determine the degree of accuracy and consistency of the measure to represent latent satisfaction judgements. To obtain a complete understanding of the validity of the performance criteria, three types of validity were tested, namely content validity, criterion-related validity (concurrent validity) and construct validity. To test the reliability of the satisfaction measure, the internal consistency method, specifically coefficient Cronbach's alpha, was used because of the practicality and robustness of alpha as an estimate of reliability. Since the methods of validity and reliability assessment were normally employed in the assessment of validity and reliability of multiple measures, the relationships between *totsat* and satisfaction measures were emphasised. *Totsat* demonstrated extremely high correlations with valid and reliable satisfaction measures which could be deemed as evidence of the validity and reliability of *totsat*.

14.2.11 Development of Models of Satisfaction for Each Participant

The models of satisfaction were developed using multiple regression (MR) and artificial neural network (ANN) techniques based on the overall satisfaction (*totsat*) as the dependent variable, and attributes as independent variables. The MR technique was chosen because of its ability to predict levels of satisfaction and because some degree of linear relationship was found between dependent and independent variables in preliminary data examination. The ANN technique was applied because of the nature of the research problem which suggested that a somewhat more 'sophisticated' tool was needed to reveal the attributes underlying complex and noisy (i.e. very subjective) satisfaction judgements. The utilisation of these two distinct techniques provided an opportunity to compare the performance of both techniques. Additionally, significant independent variables identified by one technique could also be compared against those identified by the other. Twelve models, i.e. six models for each technique, have been developed to describe satisfaction levels of each participant based on the other participant's performance. The capability of the client's representative and project architect, the past performance of the contractor, and procurement route, were found to be the most important independent variables.

14.2.12 Validation of the Models Using Independent Data

To confirm the validity of the models, they were tested against independent data. Two measures of predictive performance, i.e. mean absolute deviation (MAD) and mean absolute percentage error (MAPE) were used to gauge the relative deviation of the predicted levels to the actual levels of satisfaction (i.e. residual). The results indicated that the deviation of the predicted levels from the actual levels of satisfaction were within acceptable limits. The Pearson's correlation and chi-square (χ^2) tests were then used to confirm the accuracy and consistency of the predicted levels of satisfaction. The results indicated that the models' predicted levels of satisfaction were accurate and consistent confirming the research hypothesis (refer to Chapter 1, section 1.2). Overall, the models developed were found to be valid and robust and thereby can be used to predict levels of satisfaction within the construction PC.

14.2.13 Dissemination of Research Findings

The research findings have been disseminated in refereed journals (such as *International Journal of Quality and Reliability Management, Journal of Construction Procurement*) and conference proceedings (such as *ARCOM '99* and *'01*), and presented at various seminars (such as *CIOB Construction Research Seminar*). Further publications are anticipated in the near future as a result of the research (see for example, Soetanto and Proverbs, 2002a-c inclusive). Moreover, a summary of the main research findings have been forwarded to PC participants who participated in the research interviews and surveys. These have made the findings accessible to an audience including academics and practitioners.

14.3 LIMITATIONS OF THE RESEARCH

Several limitations of this research are presented in the following:

- Due to mainly time and resource constraints, the analysis was conducted using a relatively limited database (in terms of quantity) for research of this kind, i.e. research that involves subjective (psychological) judgements. Moreover, the survey instruments (i.e. questionnaires) to some extent, hamper deeper analysis being conducted. For example, the attributes may not be exhaustive or may not appropriately portray satisfaction levels. This is particularly true for satisfaction attributes since these attributes have not been well researched in the past. Ideally, this demands a deeper method of data collection, such as in-depth interviews and focus groups. Conversely, performance attributes have been well developed based on previous research in this area. Therefore, their inclusion was relatively extensive.
- The respondents to the survey were mainly senior managers. It is acknowledged that their perceptions may be different to those at different levels in the organisation. While the satisfaction of such senior managers may be considered to be of high priority, it is acknowledged that the findings may have been different if for example site personnel had been targeted.

14.4 RECOMMENDATIONS FOR FURTHER RESEARCH

The results of this research provide a sound foundation for further development, as described in the following:

- The models could be further refined and improved using a larger database of respondents. This larger sample may help to derive more accurate and consistent models.

- The thorough identification of satisfaction attributes, for this kind of research would be more effectively achieved using in-depth interview methods. This would also allow the significance of subjectivity to be further investigated including the dilemma concerning the modelling technique employed.
- Development of a tool linking the statistical models to an interactive / more user-friendly software (possibly in the form of an expert system) could ease the practical application of the models as described in section 13.3.
- The influence of procurement route on satisfaction is an area worthy of further specific investigation. Here, satisfaction levels could be compared (e.g.) on projects with traditional (i.e. competitive tendering) and non-traditional routes (design and build, long-term partnering or strategic alliances) in order that a greater understanding of their impact could be gained.

14.5 SUMMARY

This chapter has discussed the conclusions of the research work including a review of the original research objectives, limitations of the research, and recommendations for possible further research.

To summarise this research, models have been developed and could be used to predict satisfaction levels, help improve performance and enhance levels of satisfaction. This ultimately would help to create a performance-enhancing environment leading to harmonious working relationships between project coalition participants, and so ensure continuous performance improvement for the betterment of all involved.

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Appendices

Appendix A:

Covering Letters for Interview and Questionnaire Survey

February 8, 1999

Sir Norman Foster
FOSTER AND PARTNERS
Riverside Three
Albert Wharf
22 Hester Road
London SW11 4AN

Dear Sir Foster,

I am a Ph.D. research student within the Built Environment Research Unit at the University of Wolverhampton. I am conducting research aimed at developing a predictive model for optimising the relationship between main construction participants, i.e. *client, contractor* and *architect.* Enclosed is an overview of my research.

The recent report by Sir John Egan (July 1998) highlights "*....more than a third of major clients are dissatisfied with contractors' and consultants' performance....*" It is clear that too many clients are dissatisfied with the performance of the construction industry. However, evidence suggests that contractors and architects are also dissatisfied with the performance of other project participants. This enhances the strongly ingrained adversarial culture in the construction project environment. To help address this issue all project participants should be aware of their own performance and the performance of other participants. Identifying and improving this performance interaction is the objective of my research.

To help achieve this objective, I require information relating to the interrelationships, and performance and satisfaction attributes of the project participants. Therefore, the opportunity to interview a suitable member of staff (preferably at the Project Management level) would be much appreciated. The interview will take about thirty minutes.

If you are willing, please complete the attached reply form indicating a convenient appointment (preferably within two weeks) and details of the person. A SAE is enclosed for this purpose.

Your contribution to this research is very important. All information provided will be held in strict confidence and used for research purposes only.

I look forward to your response.

Yours sincerely,

Mr. Robby Soetanto
Doctoral Research Student
Built Environment Research Unit

E-mail: R.Soetanto@wlv.ac.uk
Phone: 01902-322108
Fax: 01902-322743

30th June 2000

«Title» «Firstname» «Surname»
«Company»
«Building__PO_Box»
«Road__Street»
«Suburb»
«Town» «Postcode»

Dear «Title» «Surname»,

We are presently conducting research aimed at developing a predictive model for optimising the relationship between main construction participants, i.e. *client*, *contractor* and *architect*, and would appreciate your assistance and co-operation in this final stage of data collection.

Sir John Egan's report (July 1998) highlighted that "*....more than a third of major clients are dissatisfied with contractors' and consultants' performance....*" It is clear that too many clients are dissatisfied with the performance of the construction industry. However, evidence suggests that contractors and architects are also dissatisfied with the performance of their fellow construction participants. This only serves to enhance the adversarial culture of the construction project environment. To help address this issue all project participants should be aware of the performance interaction that exists between them. Identifying and improving this performance interaction is the principal objective of the research.

A questionnaire aimed at collecting relevant information from project participants is enclosed and we would be grateful if you could complete and return it using the self addressed envelope provided (preferably within 10 working days). The questionnaire has been carefully designed to allow its rapid and effective completion.

Our research relies on receiving replies from companies such as yourselves and you have our assurance that all information provided will be held in strict confidence and used for research purposes only.

Please do not hesitate to contact me should you wish to discuss the questionnaire or address any queries. Your assistance is much valued and appreciated.

Yours sincerely,

Dr. David G. Proverbs
Senior Research Fellow
Built Environment Research Unit

E-mail: D. Proverbs@wlv.ac.uk
Phone: 01902-322786
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Appendix B:

Questionnaires for First Stage Survey

Performance and Satisfaction Research
(Client Questionnaire)

This questionnaire represents part of a research programme aimed at developing a predictive model of performance and satisfaction for the three main participants in the construction project coalition, i.e. clients, contractors and architects. This predictive model will enable members of the project coalition to foresee problems and forecast performance before project commencement. For example, clients of the construction industry will be able to predict the performance of their chosen contractors and architects allowing appropriate corrective actions to be implemented, e.g. to mitigate under-performing contractors and architects so that overall project performance can be improved.

We would like you to consider a recent (i.e. last 2 years) building project that you have procured from the construction industry (referred to hereafter as the 'case project'). Preferably, but not exclusively, this 'case project' should be located in the UK and have been procured using the traditional route or a form of partnering. Here, the traditional procurement route is defined as the method of procuring a building in which professionals and contractor are independently employed by the client using separate contracts, whereas partnering is where all participants involved are engaged in long term relationships, which may involve the construction of a project or a series of projects for the 'agreed common objectives', for the purpose of continuous improvements. You will need to relate all your responses to the questions in this questionnaire to this one case project. Due to the nature of the information requested, we have deliberately designed the questionnaire to avoid identifying projects, naming other participants, etc. The first section of the questionnaire seeks information concerning you and your company. The second section seeks to categorise the characteristics of the case project. The final sections ask you to indicate the attributes and the levels of satisfaction of key participant performance criteria, again for the case project. Please note, if you have other attributes, characteristics or criteria, please feel free to comment and add. All the information provided will be held in strict confidence and used for research purposes only. A SAE is enclosed for your convenience.

Many of the questions presented require you to indicate your response on a scale. For example: How would you gauge the complexity of the case project:

Easy Highly complex

0 1 2 3 4 5 ⑥ 7 8 9 10

If you considered the case project to be, say somewhat complicated, you may rate the complexity a value of 6, and therefore circle this value to indicate your response as shown.

If you would like further information or have any queries, please do not hesitate to contact me. If you would like to receive a summary of the research findings, please tick here □.

Thank you for your kind attention and assistance.

Dr. David G. Proverbs
Senior Research Fellow
Built Environment Research Unit
School of Engineering and the Built Environment
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Section 1 - Your details

Respondent Details

Your name : .... Name of Employer : ....

Your position : .... Department : ....

Contact address : ....

Telephone : .... Fax : ....E-mail: ....

Respondent Attributes

R01. What is your vocational background?

□ architect □ quantity surveyor □ engineering □ construction managemt □ other, please specify ....

R02. How long have you been: a) involved in building construction projects? ....years
R03. b) working for this company? ....years

R04. How many similar projects (to the 'case project') have you been involved in the last five years? ....projects

How would you gauge your overall satisfaction of all projects you have undertaken in terms of the following:

	Satisfaction in terms of	Dissatisfied Satisfied
R05.	Overall project performance	0 1 2 3 4 5 6 7 8 9 10
R07.	Architect performance	0 1 2 3 4 5 6 7 8 9 10
R08.	Contractor performance	0 1 2 3 4 5 6 7 8 9 10

Please indicate your general perception on the following statements concerning architects in the UK construction industry

	Perception of architects	False True
R16.	Don't listen to views of other coalition members	0 1 2 3 4 5 6 7 8 9 10
R17.	More interested in design aesthetics than buildability	0 1 2 3 4 5 6 7 8 9 10
R18.	Unable to meet deadlines (late information delivery)	0 1 2 3 4 5 6 7 8 9 10
R19.	Poor management skills	0 1 2 3 4 5 6 7 8 9 10
R20.	Poor technical skills	0 1 2 3 4 5 6 7 8 9 10
R21.	Unreliable	0 1 2 3 4 5 6 7 8 9 10
R22.	Disorganised	0 1 2 3 4 5 6 7 8 9 10

Please indicate your general perception on the following statements concerning contractors in the UK construction industry

	Perception of contractors	False True
R23.	Cowboy builders	0 1 2 3 4 5 6 7 8 9 10
R24.	Too willing to 'build claims'	0 1 2 3 4 5 6 7 8 9 10
R25.	Never finish projects on time	0 1 2 3 4 5 6 7 8 9 10
R26.	Contractual	0 1 2 3 4 5 6 7 8 9 10
R27.	Wasteful / untidy	0 1 2 3 4 5 6 7 8 9 10
R28.	Unproductive / inefficient	0 1 2 3 4 5 6 7 8 9 10
R29.	Slow to adopt new technology / innovations	0 1 2 3 4 5 6 7 8 9 10

Company Attributes

F01. What is the nature of your company business?
☐ retail ☐ finance ☐ industrial ☐ other, please specify ....

F02. How long has your company been established? ....years

F03. How many people are employed by your company? ....employees

F04. What is the annual turnover of your company? £.......................

Total annual building works that your company has procured in last financial year:

F05/F06. No. of projects: .... Total value: £ ....

Section 2 - 'Case project' attributes

Please relate all following responses to just one recent 'case project' as described previously.

P01. Type of project:
☐ new building ☐ refurbishment ☐ extension to existing premises ☐ other, please specify ....

P02. Type of building:
☐ office ☐ retail ☐ residential ...... ☐ industrial ...... ☐ public ...... ☐ other, please specify ......

P03. How many storeys? ....storeys

P04. Approximate gross floor area of the building? ....ft^2 / m^2 (choose one)

P05. How many similar types of project has your company procured within the last five years? ....projects

P06. What procurement route did you adopt on this project?
☐ traditional ☐ design and build ☐ partnering ☐ other, specify.............

P07. What type of contract did you use on this project?
☐ JCT form ☐ ICE ☐ NEC ☐ other, specify.............

P08. How would you assess the clarity of the form of contract used on the case project?
Ambiguous (e.g. bespoke contracts) 0 1 2 3 4 5 6 7 8 9 10 Clear, unambiguous (e.g. common building contracts)

P09. What was the planned duration of the project? ....months

P10. Did the project overrun? Yes / No (choose)
P11. If so, by how much time? .... days/weeks/months (choose)

P12. What was the tender sum for the project? £ ....

P13. Did the project finish overbudget? Yes / No (choose)
P14. If so, by how much money? £ ....

P15. How would you gauge the severity (<u>in terms of value</u>) of variations on this case project?
Least severe 0 1 2 3 4 5 6 7 8 9 10 Most severe

P16. How would you gauge the frequency of variations on this case project?
Least frequent 0 1 2 3 4 5 6 7 8 9 10 Most frequent

With regard to the source or cause of these variations, how would you assess the contribution of the following parties?

	Cause of Variations	Never Always
P17.	Client	0 1 2 3 4 5 6 7 8 9 10
P18.	Architect	0 1 2 3 4 5 6 7 8 9 10
P19.	Contractor	0 1 2 3 4 5 6 7 8 9 10
P20.	Others (unforeseen , miscellaneous)	0 1 2 3 4 5 6 7 8 9 10

P21. How would you gauge the level of design complexity on this project?

Easy /typical 0 1 2 3 4 5 6 7 8 9 10 Extremely complex

P22. How would you gauge the level of construction complexity on this project?

Easy /typical 0 1 2 3 4 5 6 7 8 9 10 Extremely complex

P23. In percentage terms, at the commencement of construction works on site, how much of the design had been completed? ....%

P24. How long did design stage (i.e. prior to on-site work) take? ....months

How would you gauge the impact of the following constraints on overall project performance?

	Constraints	No impact Very high impact
P25.	Ground conditions	0 1 2 3 4 5 6 7 8 9 10
P26.	Weather conditions	0 1 2 3 4 5 6 7 8 9 10
P27.	Government regulations (e.g. planning permit)	0 1 2 3 4 5 6 7 8 9 10

With regard to the location of the project, please indicate the following:

P28. The ease of access to the site

Extremely poor 0 1 2 3 4 5 6 7 8 9 10 Excellent
e.g. city centre e.g. green field

	Remoteness from	Local (within 10 mile radius) Distant (more than 300 miles radius)
P29.	your office	0 1 2 3 4 5 6 7 8 9 10
P30.	architect home office	0 1 2 3 4 5 6 7 8 9 10
P31.	contractor home office	0 1 2 3 4 5 6 7 8 9 10

P32. How would you gauge the interaction between contractor and architect prior to on site work?

Low 0 1 2 3 4 5 6 7 8 9 10 High

Section 3 - Contractor attributes and performance criteria

In the following sections, you will be asked questions concerning the contractor employed on the 'case project'. Note: You will not be asked to reveal the identification of the company.

O01. Operationally, what size (in terms of catchment) was the contractor?

☐ local ☐ regional ☐ national ☐ international

O02. Approximately, what was the annual turnover of the contractor?

☐ up to £ 10 m. ☐ £ 10 to £ 100 m. ☐ £ 100 to £ 500 m. ☐ above £ 500 m.

O03. How many employees did the contractor have?

☐ less than 20 ☐ 21 to 100 ☐ 101 to 1000 ☐ above 1000

O04. How long has the contractor company been established? .... years (approx.)

O05. On how many projects has your company worked with this contractor before? ....projects

O06. What was your method of contractor selection?

☐ competitive tendering ☐ two stage competitive tendering ☐ negotiation ☐ other, specify................

Please indicate the levels of importance of the following contractor selection criteria on the case project:

	Contractor selection criteria	Level of Importance low extremely high										
O07.	Technical ability (execution method)	0	1	2	3	4	5	6	7	8	9	10
O08.	Past experience / performance	0	1	2	3	4	5	6	7	8	9	10
O09.	Quality and programme	0	1	2	3	4	5	6	7	8	9	10
O10.	Third party references/ recommendations	0	1	2	3	4	5	6	7	8	9	10
O11.	Tender sum	0	1	2	3	4	5	6	7	8	9	10
O12.	Reputation	0	1	2	3	4	5	6	7	8	9	10

O13. How would you gauge the extent of contractor evaluation prior to contract award?

Minimum evaluation (e.g. only references) 0 1 2 3 4 5 6 7 8 9 10 Thorough evaluation of all aspects

O14. How would you gauge the contractor's work load when executing the case project?

No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

O15. What was your method of contractor payment?

☐ lump sum ☐ unit price ☐ cost reimbursement ☐ other, specify.............................

O16. What was the difference between contractor bid and your estimate: £ ....

Was the bid more or less than your estimate? More / Less (please choose)

O17. What was the difference between contractor bid and second lowest bidder: £ ....

O18. What influence did you have on appointment of the contractor's site personnel to the project:?

No influence 0 1 2 3 4 5 6 7 8 9 10 Strong influence

O19. Have you previously worked with the contractor's site personnel appointed to this project? Yes / No (choose)

Please score the following attributes of the contractor on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Contractor Attributes	Negative										Positive
O20.	Financial soundness (i.e. stability and status)	0	1	2	3	4	5	6	7	8	9	10
O21.	Experience in the type of case project	0	1	2	3	4	5	6	7	8	9	10
O22.	Experience in the size of case project	0	1	2	3	4	5	6	7	8	9	10
O23.	Experience in geographical location of case project	0	1	2	3	4	5	6	7	8	9	10
O24.	References from other clients and consultants	0	1	2	3	4	5	6	7	8	9	10
O25.	Past performance in the last project (before case project)	0	1	2	3	4	5	6	7	8	9	10
O26.	Reputation in on time completion	0	1	2	3	4	5	6	7	8	9	10
O27.	Reputation in on budget completion	0	1	2	3	4	5	6	7	8	9	10
O28.	Reputation in product quality / workmanship	0	1	2	3	4	5	6	7	8	9	10
O29.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0	1	2	3	4	5	6	7	8	9	10
O30.	Reputation in claims (*note:* **Positive** *means not claim conscious*)	0	1	2	3	4	5	6	7	8	9	10
O31.	Qualification and experience of director	0	1	2	3	4	5	6	7	8	9	10
O32.	Qualification and experience of site personnel /P.M.	0	1	2	3	4	5	6	7	8	9	10
O33.	Health and safety past performance and policy	0	1	2	3	4	5	6	7	8	9	10
O34.	Formal training regime for site personnel	0	1	2	3	4	5	6	7	8	9	10
O35.	Quality control policy	0	1	2	3	4	5	6	7	8	9	10
O36.	Industrial relation: knowledge of local subs and suppliers	0	1	2	3	4	5	6	7	8	9	10
O37.	Industrial relation: knowledge of local labour	0	1	2	3	4	5	6	7	8	9	10
O38.	Plant resource available (ownership or ease of hire)	0	1	2	3	4	5	6	7	8	9	10
O39.	Previous working relationship between client and contractor	0	1	2	3	4	5	6	7	8	9	10

In respect of achieving your project objectives for the 'case project' please indicate your levels of satisfaction acquired for each of the following contractor performance indicators.

Contractor Performance Criteria	Level of Satisfaction on case project low high
Pre-construction Stage	
• First interview and presentation	0 1 2 3 4 5 6 7 8 9 10
• Ability and willingness to help develop brief	0 1 2 3 4 5 6 7 8 9 10
• Contribution to design and buildability of project	0 1 2 3 4 5 6 7 8 9 10
• Plan of work and method statement	0 1 2 3 4 5 6 7 8 9 10
• Understanding of contract and specifications	0 1 2 3 4 5 6 7 8 9 10
Construction Stage *Site management*	
• Site supervision and control	0 1 2 3 4 5 6 7 8 9 10
• Site organisation, tidiness and cleanliness	0 1 2 3 4 5 6 7 8 9 10
• Ability to plan and programme properly	0 1 2 3 4 5 6 7 8 9 10
• Health and safety performance / management	0 1 2 3 4 5 6 7 8 9 10
• Compliance to regulations (CDM, etc.)	0 1 2 3 4 5 6 7 8 9 10
Resource management	
• Material management	0 1 2 3 4 5 6 7 8 9 10
• Man power management (sufficient quantity and quality of craftsmen)	0 1 2 3 4 5 6 7 8 9 10

Contractor Performance Criteria	Level of Satisfaction on case project low high
• Equipment and plant management	0 1 2 3 4 5 6 7 8 9 10
• Managt. and co-ord. of subcontractors and suppliers	0 1 2 3 4 5 6 7 8 9 10
• Payment to subcontractors and suppliers (on time)	0 1 2 3 4 5 6 7 8 9 10
• Strength of contractor site team (i.e. quantity)	0 1 2 3 4 5 6 7 8 9 10
• Concern/awareness for environmental issues	0 1 2 3 4 5 6 7 8 9 10
Site personnel	
• Cooperation with client (i.e. client representative)	0 1 2 3 4 5 6 7 8 9 10
• Individual performance and ability	0 1 2 3 4 5 6 7 8 9 10
• Proj. manager performance and adequacy of authority	0 1 2 3 4 5 6 7 8 9 10
• Site manner (i.e. no loud noises and swearing)	0 1 2 3 4 5 6 7 8 9 10
Variations and drawings	
• Processing variations (e.g. speed, flexibility)	0 1 2 3 4 5 6 7 8 9 10
• Preparation of shop drawings and as-built drawings	0 1 2 3 4 5 6 7 8 9 10
• Contribution to development of design drawings	0 1 2 3 4 5 6 7 8 9 10
Completion Stage & Ease of Delivery	
• Completion of defects	0 1 2 3 4 5 6 7 8 9 10
• Smoothness of operation and hand-over	0 1 2 3 4 5 6 7 8 9 10
• Quality of hand-over document (O&M manual, H&S)	0 1 2 3 4 5 6 7 8 9 10
• Ease / speed of settlement of final account	0 1 2 3 4 5 6 7 8 9 10
• Ease of delivery (general feeling on how things went)	0 1 2 3 4 5 6 7 8 9 10
Principal	
• Adherence to schedule (time performance)	0 1 2 3 4 5 6 7 8 9 10
• Adherence to budget (cost performance)	0 1 2 3 4 5 6 7 8 9 10
• Quality of construction and workmanship	0 1 2 3 4 5 6 7 8 9 10
Quality of Service	
• Handling of complaints (effectiveness)	0 1 2 3 4 5 6 7 8 9 10
• Telephone inquiries and correspondence handled courteously and adequately	0 1 2 3 4 5 6 7 8 9 10
• Speed and reliability of service	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to client	0 1 2 3 4 5 6 7 8 9 10
• Ability to make rapid decisions	0 1 2 3 4 5 6 7 8 9 10
• Commitment of key person (active & continuous)	0 1 2 3 4 5 6 7 8 9 10
• Corporate hospitality	0 1 2 3 4 5 6 7 8 9 10
• Administration	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Honesty and integrity	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Customer focus / proactive to understand client	0 1 2 3 4 5 6 7 8 9 10
• Keep the client informed	0 1 2 3 4 5 6 7 8 9 10
• Communication (to coalition member & site person)	0 1 2 3 4 5 6 7 8 9 10
• Pro-active attitude toward problems	0 1 2 3 4 5 6 7 8 9 10
• Avoidance of claims (i.e. not claims conscious)	0 1 2 3 4 5 6 7 8 9 10
• Responsibility for their decision (understand the cost of his recommendation)	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of contractor performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the contractor?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

Section 4 - Architect attributes and performance criteria

In the following sections, you will be asked questions concerning the architect employed on the 'case project'. Note: You will not be asked to reveal the identification of the architect or architect company. If the 'case project' was design and build, please do your best to answer these questions, by assessing the provision of these services by the contractor.

A01. Operationally, what size (in terms of catchment) was the architectural practice?
☐ local ☐ regional ☐ national ☐ international

A02. Approximately, what was the annual fee turnover of the architectural practice?
☐ up to £ 1m. ☐ £ 1to £ 5 m. ☐ £ 5 to £ 50 m. ☐ above £ 50 m.

A03. How many employees did the architectural practice have?
☐ less than 10 ☐ 11 to 50 ☐ 51 to 200 ☐ above 200

A04. How long has the architectural practice been established? .... years (approx.)

A05. On how many projects has your company worked with this architect before? ....projects

A06. What was your method of architect selection?
☐ one to one negotiation ☐ competitive interview ☐ fee tender ☐ other, specify.....................

Please indicate the levels of importance of the following architect selection criteria on the case project:

	Architect selection criteria	Level of Importance low ... extremely high										
A07.	Technical ability	0	1	2	3	4	5	6	7	8	9	10
A08.	Past experience / performance	0	1	2	3	4	5	6	7	8	9	10
A09.	Quality and design flair	0	1	2	3	4	5	6	7	8	9	10
A10.	Third party references/ recommendations	0	1	2	3	4	5	6	7	8	9	10
A11.	Fee	0	1	2	3	4	5	6	7	8	9	10
A12.	Reputation	0	1	2	3	4	5	6	7	8	9	10

A13. How would you gauge the extent of architect evaluation prior to engagement?
Minimum evaluation (e.g. only references) 0 1 2 3 4 5 6 7 8 9 10 Thorough evaluation of all aspects

A14. How would you gauge the architect's work load when executing this project?
No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

A15. What was your method of architect payment?
☐ lump sum fee ☐ percentage cost ☐ other, specify............................

A16. As percentage to total project cost, what was architect design fee? ....%

A17. What influence did you have on appointment of architect's personnel to the project:?
No influence 0 1 2 3 4 5 6 7 8 9 10 Strong influence

A18. Have you previously worked with the project architects appointed to this project? Yes / No (choose)

Please score the following attributes of the architect on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Architect Attributes	**Negative**										**Positive**
A19.	Financial soundness (i.e. stability and status)	0	1	2	3	4	5	6	7	8	9	10
A20.	Experience in the type of case project	0	1	2	3	4	5	6	7	8	9	10
A21.	Experience in the size of case project	0	1	2	3	4	5	6	7	8	9	10
A22.	Experience in geographical location of case project	0	1	2	3	4	5	6	7	8	9	10
A23.	References from other clients	0	1	2	3	4	5	6	7	8	9	10
A24.	Past performance in the last project (before case project)	0	1	2	3	4	5	6	7	8	9	10
A25.	Reputation in speed of information delivery	0	1	2	3	4	5	6	7	8	9	10
A26.	Reputation in adherence to budget	0	1	2	3	4	5	6	7	8	9	10
A27.	Reputation in quality of design	0	1	2	3	4	5	6	7	8	9	10
A28.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0	1	2	3	4	5	6	7	8	9	10
A29.	Reputation in commercial attitude (e.g. additional fee)	0	1	2	3	4	5	6	7	8	9	10
A30.	Qualification and experience of director / principal	0	1	2	3	4	5	6	7	8	9	10
A31.	Qualification and experience of project architect	0	1	2	3	4	5	6	7	8	9	10
A32.	Quality assurance system	0	1	2	3	4	5	6	7	8	9	10
A33.	Previous working relationship between client and architect	0	1	2	3	4	5	6	7	8	9	10

In respect of achieving your project objectives for the 'case project', please indicate your levels of satisfaction acquired for each of the following architect performance indicators.

Architect Performance Criteria	**Level of Satisfaction on case project** low										high
Pre-construction Stage											
• First interview and design presentation (visibility)	0	1	2	3	4	5	6	7	8	9	10
• Ability to develop brief and resolution of the brief	0	1	2	3	4	5	6	7	8	9	10
• Method statement (ability to explain how the project will be handled)	0	1	2	3	4	5	6	7	8	9	10
• Understanding of client culture (e.g. nature of client company) to assess the real need	0	1	2	3	4	5	6	7	8	9	10
Quality of Design											
• Design suitability to solution (relevancy, practicallity)	0	1	2	3	4	5	6	7	8	9	10
• Design buildability / constructability	0	1	2	3	4	5	6	7	8	9	10
• Design flair or aesthetic sense and innovation	0	1	2	3	4	5	6	7	8	9	10
• Design to provide value for money	0	1	2	3	4	5	6	7	8	9	10
• Design to incorporate health and safety issues	0	1	2	3	4	5	6	7	8	9	10
• Design concern for environmental issues	0	1	2	3	4	5	6	7	8	9	10
• Design simplicity for operations and maintenance	0	1	2	3	4	5	6	7	8	9	10
• Design adaptability or sustainability	0	1	2	3	4	5	6	7	8	9	10
• Quality of detail drawing and specifications (e.g. accuracy, completeness)	0	1	2	3	4	5	6	7	8	9	10
Management Skill											
• Design management and supervision	0	1	2	3	4	5	6	7	8	9	10
• Ability to manage the construction process (as contract administrator)	0	1	2	3	4	5	6	7	8	9	10
• Coordination between team members or consultants	0	1	2	3	4	5	6	7	8	9	10
• Company organisational skills & org. structure	0	1	2	3	4	5	6	7	8	9	10
• Management of resources (commitment of resources)	0	1	2	3	4	5	6	7	8	9	10

Architect Performance Criteria	Level of Satisfaction on case project low high
Technical Skill	
• Practical construction knowledge	0 1 2 3 4 5 6 7 8 9 10
• Suitability and quality of major building components or products selected	0 1 2 3 4 5 6 7 8 9 10
• Incorporation of mechanical and electrical services into the structure	0 1 2 3 4 5 6 7 8 9 10
• Understanding and compliance with legislation and statutory requirements (CDM, fire regl., etc.)	0 1 2 3 4 5 6 7 8 9 10
Quality of Services	
• Effective handling of complaints	0 1 2 3 4 5 6 7 8 9 10
• Telephone inquiries and correspondence handled courteously and adequately	0 1 2 3 4 5 6 7 8 9 10
• Speed and reliability of service (e.g. redrawing)	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to client queries (flexibility)	0 1 2 3 4 5 6 7 8 9 10
• Ability to make rapid and decisive decisions	0 1 2 3 4 5 6 7 8 9 10
• Commitment of key persons (active & continuous)	0 1 2 3 4 5 6 7 8 9 10
• Willingness to draft the documents / drawings, not only do conceptual work	0 1 2 3 4 5 6 7 8 9 10
• Follow up (e.g. defects) or services offered after project completion	0 1 2 3 4 5 6 7 8 9 10
• Corporate hospitality	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Integrity	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Keep the client informed (willingness to involve cl.)	0 1 2 3 4 5 6 7 8 9 10
• Communication with other coalition members	0 1 2 3 4 5 6 7 8 9 10
• Commercial attitude (e.g. additional fees)	0 1 2 3 4 5 6 7 8 9 10
• Pro-active to know site problems (e.g. by regular site visit)	0 1 2 3 4 5 6 7 8 9 10
• Attitude in dealing with client and contractor	0 1 2 3 4 5 6 7 8 9 10
• Avoidance of design changes	0 1 2 3 4 5 6 7 8 9 10
• Listen to what client wants (customer focus)	0 1 2 3 4 5 6 7 8 9 10
• Responsibility for their decision (understand the cost of their recommendations)	0 1 2 3 4 5 6 7 8 9 10
Main Criteria	
• General quality of building (both functionality and aesthetics)	0 1 2 3 4 5 6 7 8 9 10
• Compliance with information required schedule	0 1 2 3 4 5 6 7 8 9 10
• Compliance with requirements	0 1 2 3 4 5 6 7 8 9 10
• Compliance to budget	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of architect performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the architect?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

This is the end of questionnaire. Thank you very much for your help.

Performance and Satisfaction Research
(Architect Questionnaire)

This questionnaire represents part of a research programme aimed at developing a predictive model of performance and satisfaction for the three main participants in the construction project coalition, i.e. clients, contractors and architects. This predictive model will enable members of the project coalition to foresee problems and forecast performance before project commencement. For example, architects will be able to predict the performance of their clients and contractors allowing appropriate corrective actions to be implemented, e.g. to mitigate under-performing clients and contractors so that overall project performance can be improved.

We would like you to consider a recent (i.e. last 2 years) building project that your company designed (referred to hereafter as the 'case project'). Preferably, but not exclusively, this 'case project' should be located in the UK and have been procured using the traditional route or a form of partnering. <u>You will need to relate all your responses to the questions in this questionnaire to this one case project</u>. Due to the nature of the information requested, we have deliberately designed the questionnaire to avoid identifying projects, naming other participants, etc. The first section of the questionnaire seeks information concerning you and your company. The second section seeks to categorise the characteristics of the case project. The final sections ask you to indicate the attributes and the levels of satisfaction of key participant performance criteria, again for the case project. Please note, if you have other attributes, characteristics or criteria, please feel free to comment and add. <u>All the information provided will be held in strict confidence and used for research purposes only</u>. A SAE is enclosed for your convenience.

Many of the questions presented require you to indicate your response on a scale. For example:
How would you gauge the complexity of the case project:

Easy Highly complex

0 1 2 3 4 5 6 7 8 9 10

If you considered the case project to be, say somewhat complicated, you may rate the complexity a value of 6, and therefore circle this value to indicate your response as shown.

If you would like further information or have any queries, please do not hesitate to contact me. If you would like to receive a summary of the research findings, please tick here ☐.

Thank you for your kind attention and assistance.

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Section 1 - Your details

Respondent Details

Your name : .... Name of Employer : ....

Your position : .... Department : ....

Contact address : ....

Telephone : .... Fax : ....E-mail: ....

Respondent Attributes

R01. What is your vocational background?

☐ architect ☐ quantity surveyor ☐ engineering ☐ construction managemt. ☐ other, please specify .....

R02. How long have you been: a) involved in designing construction projects? ....years

R03. b) working for this company? ....years

R04. How many similar projects (to the 'case project') have you been involved in the last five years? ....projects

How would you gauge your overall satisfaction of all projects you have undertaken in terms of the following:

	Satisfaction in terms of	Dissatisfied … Satisfied
R05.	Overall project performance	0 1 2 3 4 5 6 7 8 9 10
R06.	Client performance	0 1 2 3 4 5 6 7 8 9 10
R08.	Contractor performance	0 1 2 3 4 5 6 7 8 9 10

Please indicate your general perception on the following statements concerning clients in the UK construction industry

	Perception of clients	False … True
R09.	Do not know what they want	0 1 2 3 4 5 6 7 8 9 10
R10.	Always changing their mind	0 1 2 3 4 5 6 7 8 9 10
R11.	Remote from construction process	0 1 2 3 4 5 6 7 8 9 10
R12.	Never pay on time	0 1 2 3 4 5 6 7 8 9 10
R13.	Do not listen to alternative ideas	0 1 2 3 4 5 6 7 8 9 10
R14.	Always want to minimise cost without considering quality	0 1 2 3 4 5 6 7 8 9 10
R15.	Tend to be influenced by their initial advisors (e.g. QS, architect)	0 1 2 3 4 5 6 7 8 9 10

Please indicate your general perception on the following statements concerning contractors in the UK construction industry

	Perception of contractors	False … True
R23.	Cowboy builders	0 1 2 3 4 5 6 7 8 9 10
R24.	Too willing to 'build claims'	0 1 2 3 4 5 6 7 8 9 10
R25.	Never finish projects on time	0 1 2 3 4 5 6 7 8 9 10
R26.	Contractual	0 1 2 3 4 5 6 7 8 9 10
R27.	Wasteful / untidy	0 1 2 3 4 5 6 7 8 9 10
R28.	Unproductive / inefficient	0 1 2 3 4 5 6 7 8 9 10
R29.	Slow to adopt new technology / innovations	0 1 2 3 4 5 6 7 8 9 10

Company Attributes

F02. How long has your company (i.e. architectural practice) been established? ....years

F03. How many people are employed by your company? ....employees

F04. What is the annual fee turnover of your company? £......................

Total annual building works that your company has undertaken in last financial year:

F05/F06. No. of projects: .... Total value: £ ....

Section 2 - 'Case project' attributes

Please relate all following responses to just one recent 'case project' as described previously.

P01. Type of project:
☐ new building ☐ refurbishment ☐ extension to existing premises ☐ other, please specify ....

P02. Type of building:
☐ office ☐ retail ☐ residential ..... ☐ industrial ..... ☐ public .... ☐ other, please specify ....

P03. How many storeys? ....storeys.

P04. Approximate gross floor area of the building? ....ft^2 / m^2 (choose one)

P05. How many similar type of projects has your company undertaken within the last five years? ....projects

P06. What procurement route did you adopt on this project?
☐ traditional ☐ design and build ☐ partnering ☐ other, specify............

P07. What type of contract did you use on this project?
☐ JCT form ☐ ICE ☐ NEC ☐ other, specify............

P08. How would you assess the clarity of the form of contract used on the case project?

Ambiguous (e.g. bespoke contracts) 0 1 2 3 4 5 6 7 8 9 10 Clear, unambiguous (e.g. common building contracts)

P09. What was the planned duration of the project? ....months

P10. Did the project overrun? Yes / No (choose)
P11. If so, by how much time? .... days/weeks/months (choose)

P12. What was the tender sum for the project? £ ....

P13. Did the project finish overbudget? Yes / No (choose)
P14. If so, by how much money? £ ....

P15. How would you gauge the severity (<u>in terms of value</u>) of variations on this case project?

Least severe 0 1 2 3 4 5 6 7 8 9 10 Most severe

P16. How would you gauge the frequency of variations on this case project?

Least frequent 0 1 2 3 4 5 6 7 8 9 10 Most frequent

With regard to the source or cause of these variations, how would you assess the contribution of the following parties?

	Cause of Variations	Never Always
P17.	Client	0 1 2 3 4 5 6 7 8 9 10
P18.	Architect	0 1 2 3 4 5 6 7 8 9 10
P19.	Contractor	0 1 2 3 4 5 6 7 8 9 10
P20.	Others (unforeseen , miscellaneous)	0 1 2 3 4 5 6 7 8 9 10

P21. How would you gauge the level of design complexity on this project?

Easy /typical 0 1 2 3 4 5 6 7 8 9 10 Extremely complex

P22. How would you gauge the level of construction complexity on this project?

Easy /typical 0 1 2 3 4 5 6 7 8 9 10 Extremely complex

P23. In percentage terms, at the commencement of construction works on site, how much of the design had been completed? ....%

P24. How long did design stage (i.e. prior to on-site work) take? ....months

How would you gauge the impact of the following constraints on overall project performance?

	Constraints	No impact Very high impact
P25.	Ground conditions	0 1 2 3 4 5 6 7 8 9 10
P26.	Weather conditions	0 1 2 3 4 5 6 7 8 9 10
P27.	Government regulations (e.g. planning permit)	0 1 2 3 4 5 6 7 8 9 10

With regard to the location of the project, please indicate the following:

P28. The ease of access to the site

Extremely poor 0 1 2 3 4 5 6 7 8 9 10 Excellent
e.g. city centre e.g. green field

	Remoteness from	Local (within 10 mile radius) Distant (more than 300 miles radius)
P30.	your office	0 1 2 3 4 5 6 7 8 9 10
P29.	client home office	0 1 2 3 4 5 6 7 8 9 10
P31.	contractor home office	0 1 2 3 4 5 6 7 8 9 10

P32. How would you gauge the interaction between contractor and architect prior to on site work?

Low 0 1 2 3 4 5 6 7 8 9 10 High

Section 3 - Contractor attributes and performance criteria

In the following sections, you will be asked questions concerning the contractor employed on the 'case project'. Note: You will not be asked to reveal the identification of the company.

O01. Operationally, what size (in terms of catchment) was the contractor?

☐ local ☐ regional ☐ national ☐ international

O02. Approximately, what was the annual turnover of the contractor?

☐ up to £ 10 m. ☐ £ 10 to £ 100 m. ☐ £ 100 to £ 500 m. ☐ above £ 500 m.

O03. How many employees did the contractor have?

☐ less than 20 ☐ 21 to 100 ☐ 101 to 1000 ☐ above 1000

O04. How long has the contractor company been established? .... years (approx.)

O05. On how many projects has your company worked with this contractor before? ....projects

O06. What was the method of contractor selection?

☐ competitive tendering ☐ two stage competitive tendering ☐ negotiation ☐ other, specify...........

Please indicate the levels of importance of the following contractor selection criteria on the case project:

	Contractor selection criteria	Level of Importance										
		low										extremely high
O07.	Technical ability (execution method)	0	1	2	3	4	5	6	7	8	9	10
O08.	Past experience / performance	0	1	2	3	4	5	6	7	8	9	10
O09.	Quality and programme	0	1	2	3	4	5	6	7	8	9	10
O10.	Third party references/ recommendations	0	1	2	3	4	5	6	7	8	9	10
O11.	Tender sum	0	1	2	3	4	5	6	7	8	9	10
O12.	Reputation	0	1	2	3	4	5	6	7	8	9	10

O13. How would you gauge the extent of contractor evaluation prior to contract award?

Minimum evaluation (e.g. only references) 0 1 2 3 4 5 6 7 8 9 10 Thorough evaluation of all aspects

O14. How would you gauge the contractor's work load when executing the case project?

No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

O15. What was the method of contractor payment?

☐ lump sum ☐ unit price ☐ cost reimbursement ☐ other, specify............................

O16. Approximately, what was the difference between contractor bid and client estimate : £ ....

Was the bid more or less than client estimate? More / Less (please choose)

O17. Approximately, what was the difference between contractor bid and second lowest bidder: £ ....

O18. What influence did you have on appointment of the contractor's site personnel to the project:?

No influence 0 1 2 3 4 5 6 7 8 9 10 Strong influence

O19. Have you previously worked with the contractor's site personnel appointed to this project? Yes / No (choose)

Please score the following attributes of the contractor on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Contractor Attributes	Negative										Positive
O20.	Financial soundness (i.e. stability and status)	0	1	2	3	4	5	6	7	8	9	10
O21.	Experience in the type of case project	0	1	2	3	4	5	6	7	8	9	10
O22.	Experience in the size of case project	0	1	2	3	4	5	6	7	8	9	10
O23.	Experience in geographical location of case project	0	1	2	3	4	5	6	7	8	9	10
O24.	References from other clients and consultants	0	1	2	3	4	5	6	7	8	9	10
O25.	Past performance in the last project (before case project)	0	1	2	3	4	5	6	7	8	9	10
O26.	Reputation in on time completion	0	1	2	3	4	5	6	7	8	9	10
O27.	Reputation in on budget completion	0	1	2	3	4	5	6	7	8	9	10
O28.	Reputation in product quality / workmanship	0	1	2	3	4	5	6	7	8	9	10
O29.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0	1	2	3	4	5	6	7	8	9	10
O30.	Reputation in claims (*note:* **Positive** *means not claim conscious*)	0	1	2	3	4	5	6	7	8	9	10
O31.	Qualification and experience of director	0	1	2	3	4	5	6	7	8	9	10
O32.	Qualification and experience of site personnel /P.M.	0	1	2	3	4	5	6	7	8	9	10
O33.	Health and safety past performance and policy	0	1	2	3	4	5	6	7	8	9	10
O34.	Formal training regime for site personnel	0	1	2	3	4	5	6	7	8	9	10
O35.	Quality control policy	0	1	2	3	4	5	6	7	8	9	10
O36.	Industrial relation: knowledge of local subs and suppliers	0	1	2	3	4	5	6	7	8	9	10
O37.	Industrial relation: knowledge of local labour	0	1	2	3	4	5	6	7	8	9	10
O38.	Plant resource available (ownership or ease of hire)	0	1	2	3	4	5	6	7	8	9	10
O39.	Previous working relationship between architect and contractor	0	1	2	3	4	5	6	7	8	9	10

In respect of achieving your project objectives for the 'case project' please indicate your levels of satisfaction acquired for each of the following contractor performance indicators.

Contractor Performance Criteria	Level of Satisfaction on case project low — high
Pre-construction Stage	
• First interview and presentation	0 1 2 3 4 5 6 7 8 9 10
• Ability and willingness to help develop brief	0 1 2 3 4 5 6 7 8 9 10
• Contribution to design and buildability of project	0 1 2 3 4 5 6 7 8 9 10
• Plan of work and method statement	0 1 2 3 4 5 6 7 8 9 10
• Understanding of contract and specifications	0 1 2 3 4 5 6 7 8 9 10
Construction Stage *Site management*	
• Site supervision and control	0 1 2 3 4 5 6 7 8 9 10
• Site organisation, tidiness and cleanliness	0 1 2 3 4 5 6 7 8 9 10
• Ability to plan and programme properly	0 1 2 3 4 5 6 7 8 9 10
• Health and safety performance / management	0 1 2 3 4 5 6 7 8 9 10
• Compliance to regulations (CDM, etc.)	0 1 2 3 4 5 6 7 8 9 10
Resource management	
• Material management	0 1 2 3 4 5 6 7 8 9 10
• Man power management (sufficient quantity and quality of craftsmen)	0 1 2 3 4 5 6 7 8 9 10
• Equipment and plant management	0 1 2 3 4 5 6 7 8 9 10

Contractor Performance Criteria	Level of Satisfaction on case project low … high
• Managt. and co-ord. of subcontractors and suppliers	0 1 2 3 4 5 6 7 8 9 10
• Payment to subcontractors and suppliers (on time)	0 1 2 3 4 5 6 7 8 9 10
• Strength of contractor site team (i.e. quantity)	0 1 2 3 4 5 6 7 8 9 10
• Concern/awareness for environmental issues	0 1 2 3 4 5 6 7 8 9 10
Site personnel	
• Cooperation with client (i.e. client representative)	0 1 2 3 4 5 6 7 8 9 10
• Individual performance and ability	0 1 2 3 4 5 6 7 8 9 10
• Proj. manager performance and adequacy of authority	0 1 2 3 4 5 6 7 8 9 10
• Site manner (i.e. no loud noises and swearing)	0 1 2 3 4 5 6 7 8 9 10
Variations and drawings	
• Processing variations (e.g. speed, flexibility)	0 1 2 3 4 5 6 7 8 9 10
• Preparation of shop drawings and as-built drawings	0 1 2 3 4 5 6 7 8 9 10
• Contribution to development of design drawings	0 1 2 3 4 5 6 7 8 9 10
Completion Stage & Ease of Delivery	
• Completion of defects	0 1 2 3 4 5 6 7 8 9 10
• Smoothness of operation and hand-over	0 1 2 3 4 5 6 7 8 9 10
• Quality of hand-over document (O&M manual, H&S)	0 1 2 3 4 5 6 7 8 9 10
• Ease / speed of settlement of final account	0 1 2 3 4 5 6 7 8 9 10
• Ease of delivery (general feeling on how things went)	0 1 2 3 4 5 6 7 8 9 10
Principal	
• Adherence to schedule (time performance)	0 1 2 3 4 5 6 7 8 9 10
• Adherence to budget (cost performance)	0 1 2 3 4 5 6 7 8 9 10
• Quality of construction and workmanship	0 1 2 3 4 5 6 7 8 9 10
Quality of Service	
• Handling of complaints (effectiveness)	0 1 2 3 4 5 6 7 8 9 10
• Telephone inquiries and correspondence handled courteously and adequately	0 1 2 3 4 5 6 7 8 9 10
• Speed and reliability of service	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to architects' queries	0 1 2 3 4 5 6 7 8 9 10
• Ability to make rapid decisions	0 1 2 3 4 5 6 7 8 9 10
• Commitment of key person (active & continuous)	0 1 2 3 4 5 6 7 8 9 10
• Corporate hospitality	0 1 2 3 4 5 6 7 8 9 10
• Administration	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Honesty and integrity	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Customer focus / proactive to understand architect	0 1 2 3 4 5 6 7 8 9 10
• Keep the architect informed	0 1 2 3 4 5 6 7 8 9 10
• Communication (to coalition member & site person)	0 1 2 3 4 5 6 7 8 9 10
• Pro-active attitude toward problems	0 1 2 3 4 5 6 7 8 9 10
• Avoidance of claims (i.e. not claims conscious)	0 1 2 3 4 5 6 7 8 9 10
• Responsibility for their decision (understand the cost of his recommendation)	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of contractor performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the contractor?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

Section 4 - Client attributes and performance criteria

In the following sections, you will be asked questions concerning the client of the 'case project'. Note: You will <u>not</u> be asked to reveal the identification of the company. If the 'case project' was design and build, please do your best to answer these questions.

C01. What is the nature of client business?

☐ retail ☐ finance ☐ industrial ☐ other, please specify ....

C02. Approximately, what was the annual turnover of the client's company?

☐ up to £ 10 m. ☐ £ 10 to £ 100 m. ☐ £ 100 to £ 500 m. ☐ above £ 500 m.

C03. How many employees did the client have?

☐ less than 20 ☐ 21 to 100 ☐ 101 to 1000 ☐ above 1000

C04. How long has the client company been established? .... years (approx.)

C05. On how many projects has your company worked with this client before? ....projects

C06. How many similar types of project has your client undertaken within the last five years (approx.)? ....projects

C07. Did the client have a separate department or division which dealt with construction? Yes / No (choose)

C08. If so, how would you gauge the capability of that department in handling construction projects?

Low 0 1 2 3 4 5 6 7 8 9 10 High

C09. How would you gauge the client's construction work load when executing the case project?

No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

C10. How would you describe the client's organisational structure when executing the case project?

Simple 0 1 2 3 4 5 6 7 8 9 10 Complex

C11. How would you describe the client's communication channel when executing the case project?

Centralised 0 1 2 3 4 5 6 7 8 9 10 Decentralised

C12. What was the extent of your client and project evaluation prior to engagement?

Minimum evaluation (e.g. only financial consideration) 0 1 2 3 4 5 6 7 8 9 10 Thorough evaluation of all aspects

C13. Have you previously worked with the client's site personnel appointed to this project? Yes / No (choose)

Please score the following attributes of the client on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Client Attributes	Negative										Positive
C14.	Financial soundness (i.e. stability and status)	0	1	2	3	4	5	6	7	8	9	10
C15.	Experience in the type of case project	0	1	2	3	4	5	6	7	8	9	10
C16.	Experience in the size of case project	0	1	2	3	4	5	6	7	8	9	10
C17.	Experience in geographical location of case project	0	1	2	3	4	5	6	7	8	9	10
C18.	Past performance generally	0	1	2	3	4	5	6	7	8	9	10
C19.	Past performance in achieving project budget	0	1	2	3	4	5	6	7	8	9	10
C20.	Past performance in achieving project schedule	0	1	2	3	4	5	6	7	8	9	10
C21.	Past performance in good quality project	0	1	2	3	4	5	6	7	8	9	10
C22.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0	1	2	3	4	5	6	7	8	9	10
C23.	Project management experience, i.e.project team organisation	0	1	2	3	4	5	6	7	8	9	10
C24.	Project monitoring experience (e.g. monitoring progress)	0	1	2	3	4	5	6	7	8	9	10
C25.	Experience with quality assurance procedures	0	1	2	3	4	5	6	7	8	9	10
C26.	Qualification and experience of client representative	0	1	2	3	4	5	6	7	8	9	10
C27.	Previous working relationship between architect and client	0	1	2	3	4	5	6	7	8	9	10

In respect of achieving your project objectives for the 'case project' please indicate your levels of satisfaction acquired for each of the following client performance indicators.

Client Performance Criteria	Level of Satisfaction on case project low high
Understanding of Project Requirements	
• Quality of brief, in terms of clarity	0 1 2 3 4 5 6 7 8 9 10
• Quality of brief, in terms of adequacy and appropriateness	0 1 2 3 4 5 6 7 8 9 10
• Understanding of building process	0 1 2 3 4 5 6 7 8 9 10
• Knowing what they want early	0 1 2 3 4 5 6 7 8 9 10
• Clarity of thinking (not changing their mind)	0 1 2 3 4 5 6 7 8 9 10
• Ability to convey what they want	0 1 2 3 4 5 6 7 8 9 10
Finance	
• Adequacy of funding for the project	0 1 2 3 4 5 6 7 8 9 10
• Timeliness of payment	0 1 2 3 4 5 6 7 8 9 10
• Ease of financial approval due to variations	0 1 2 3 4 5 6 7 8 9 10
• Willingness to fee agreement (adequate fee)	0 1 2 3 4 5 6 7 8 9 10
Decision Making	
• Ability to make rapid and decisive decisions	0 1 2 3 4 5 6 7 8 9 10
• Quality of the decisions	0 1 2 3 4 5 6 7 8 9 10
• Unity (i.e. clear and single voice)	0 1 2 3 4 5 6 7 8 9 10
Management skills	
• Delegation (give lead designer proper level of authority)	0 1 2 3 4 5 6 7 8 9 10
• Organisational skills	0 1 2 3 4 5 6 7 8 9 10
• Performance in pre-planning (early stages pf'mance)	0 1 2 3 4 5 6 7 8 9 10
• Administration	0 1 2 3 4 5 6 7 8 9 10

Client Performance Criteria	Level of Satisfaction on case project low high
Support to Contractor / Architect	
• Information support (quality, timely, etc.)	0 1 2 3 4 5 6 7 8 9 10
• Adequacy of time (achievable and realistic timescale)	0 1 2 3 4 5 6 7 8 9 10
• Providing enough resources	0 1 2 3 4 5 6 7 8 9 10
• Monitoring progress / performance	0 1 2 3 4 5 6 7 8 9 10
• Adequate continuous involvement	0 1 2 3 4 5 6 7 8 9 10
• Ability to balance between involvement and interference	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Integrity and honesty	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Commitment to project	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to problems (queries) that arise	0 1 2 3 4 5 6 7 8 9 10
• Understanding architect difficulties	0 1 2 3 4 5 6 7 8 9 10
• Attitude to variations caused by client changes	0 1 2 3 4 5 6 7 8 9 10
• Allowing architect to enjoy projects	0 1 2 3 4 5 6 7 8 9 10
• Appreciation of architecture	0 1 2 3 4 5 6 7 8 9 10
• Ability to encourage attitude of pro-activeness of all	0 1 2 3 4 5 6 7 8 9 10
• Attitude towards advice (respect, open to solutions, flexible, receptiveness towards ideas)	0 1 2 3 4 5 6 7 8 9 10
• General feeling on how enjoyable/ pleasant client	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of client performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the client?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

This is the end of questionnaire. Thank you very much for your help.

Performance and Satisfaction Research
(Contractor Questionnaire)

This questionnaire represents part of a research programme aimed at developing a predictive model of performance and satisfaction for the three main participants in the construction project coalition, i.e. clients, contractors and architects. This predictive model will enable members of the project coalition to foresee problems and forecast performance before project commencement. For example, contractors will be able to predict the performance of their clients and architects allowing appropriate corrective actions to be implemented, e.g. to mitigate under-performing clients and architects so that overall project performance can be improved.

We would like you to consider a recent (i.e. last 2 years) building project for which your company were the main contractor (referred to hereafter as the 'case project'). Preferably, but not exclusively, this 'case project' should be located in the UK and have been procured using the traditional route or a form of partnering. You will need to relate all your responses to the questions in this questionnaire to this one case project. Due to the nature of the information requested, we have deliberately designed the questionnaire to avoid identifying projects, naming other participants, etc. The first section of the questionnaire seeks information concerning you and your company. The second section seeks to categorise the characteristics of the case project. The final sections ask you to indicate the attributes and the levels of satisfaction of key participant performance criteria, again for the case project. Please note, if you have other attributes, characteristics or criteria, please feel free to comment and add. All the information provided will be held in strict confidence and used for research purposes only. A SAE is enclosed for your convenience.

Many of the questions presented require you to indicate your response on a scale. For example: How would you gauge the complexity of the case project:

Easy Highly complex

0 1 2 3 4 5 6 7 8 9 10

If you considered the case project to be, say somewhat complicated, you may rate the complexity a value of 6, and therefore circle this value to indicate your response as shown.

If you would like further information or have any queries, please do not hesitate to contact me. If you would like to receive a summary of the research findings, please tick here □.

Thank you for your kind attention and assistance.

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Section 1 - Your details

Respondent Details

Your name : .... Name of Employer : ....

Your position : .... Department : ....

Contact address : ....

Telephone : .... Fax : ....E-mail: ....

Respondent Attributes

R01. What is your vocational background?

☐ architect ☐ quantity surveyor ☐ engineering ☐ construction managemt. ☐ other, please specify ....

R02. How long have you been: a) involved in building construction projects? ....years
R03. b) working for this company? ....years

R04. How many similar projects (to the 'case project') have you been involved in the last five years? ....projects

How would you gauge your overall satisfaction of all projects you have undertaken in terms of the following:

	Satisfaction in terms of	Dissatisfied Satisfied
R05.	Overall project performance	0 1 2 3 4 5 6 7 8 9 10
R06.	Client performance	0 1 2 3 4 5 6 7 8 9 10
R07.	Architect performance	0 1 2 3 4 5 6 7 8 9 10

Please indicate your general perception on the following statements concerning clients in the UK construction industry

	Perception of clients	False True
R09.	Do not know what they want	0 1 2 3 4 5 6 7 8 9 10
R10.	Always changing their mind	0 1 2 3 4 5 6 7 8 9 10
R11.	Remote from construction process	0 1 2 3 4 5 6 7 8 9 10
R12.	Never pay on time	0 1 2 3 4 5 6 7 8 9 10
R13.	Do not listen to alternative ideas	0 1 2 3 4 5 6 7 8 9 10
R14.	Always want to minimise cost without considering quality	0 1 2 3 4 5 6 7 8 9 10
R15.	Tend to be influenced by their initial advisors (e.g. QS, architect)	0 1 2 3 4 5 6 7 8 9 10

Please indicate your general perception on the following statements concerning architects in the UK construction industry

	Perception of architects	False True
R16.	Do not listen to views other coalition members	0 1 2 3 4 5 6 7 8 9 10
R17.	More interested in design aesthetics than buildability	0 1 2 3 4 5 6 7 8 9 10
R18.	Unable to meet deadlines (late information delivery)	0 1 2 3 4 5 6 7 8 9 10
R19.	Poor management skills	0 1 2 3 4 5 6 7 8 9 10
R20.	Poor technical skills	0 1 2 3 4 5 6 7 8 9 10
R21.	Unreliable	0 1 2 3 4 5 6 7 8 9 10
R22.	Disorganised	0 1 2 3 4 5 6 7 8 9 10

Company Attributes

F02. How long has your company been established? ....years

F03. How many people are employed by your company? ....employees

F04. What is the annual turnover of your company? £.......................

Total annual building works that your company has undertaken in last financial year:

F05/F06. No. of projects: .... Total value: £ ....

Section 2 - 'Case project' attributes

Please relate all following responses to just one recent 'case project' as described previously.

P01. Type of project:
☐ new building ☐ refurbishment ☐ extension to existing premises ☐ other, please specify ....

P02. Type of building:
☐ office ☐ retail ☐ residential ..... ☐ industrial ...... ☐ public ...... ☐ other, please specify ....

P03. How many storeys? ....storeys

P04. Approximate gross floor area of the building? ....ft^2 / m^2 (choose one)

P05. How many similar types of project has your company undertaken within the last five years? ....projects

P06. What procurement route did you adopt on this project?
☐ traditional ☐ design and build ☐ partnering ☐ other, specify............

P07. What type of contract did you use on this project?
☐ JCT form ☐ ICE ☐ NEC ☐ other, specify............

P08. How would you assess the clarity of the form of contract used on the case project?

Ambiguous (e.g. bespoke contracts) 0 1 2 3 4 5 6 7 8 9 10 Clear, unambiguous (e.g. common building contracts)

P09. What was the planned duration of the project? ....months

P10. Did the project overrun? Yes / No (choose)
P11. If so, by how much time? .... days/weeks/months (choose)

P12. What was the tender sum for the project? £ ....

P13. Did the project finish overbudget? Yes / No (choose)
P14. If so, by how much money? £ ....

P15. How would you gauge the severity (<u>in terms of value</u>) of variations on this case project?

Least severe 0 1 2 3 4 5 6 7 8 9 10 Most severe

P16. How would you gauge the frequency of variations on this case project?

Least frequent 0 1 2 3 4 5 6 7 8 9 10 Most frequent

With regard to the source or cause of these variations, how would you assess the contribution of the following parties?

	Cause of Variations	Never Always
P17.	Client	0 1 2 3 4 5 6 7 8 9 10
P18.	Architect	0 1 2 3 4 5 6 7 8 9 10
P19.	Contractor	0 1 2 3 4 5 6 7 8 9 10
P20.	Others (unforeseen , miscellaneous)	0 1 2 3 4 5 6 7 8 9 10

P21. How would you gauge the level of design complexity on this project?

Easy /typical 0 1 2 3 4 5 6 7 8 9 10 Extremely complex

P22. How would you gauge the level of construction complexity on this project?

Easy /typical 0 1 2 3 4 5 6 7 8 9 10 Extremely complex

P23. In percentage terms, at the commencement of construction works on site, how much of the design had been completed? ....%

P24. How long did design stage (i.e. prior to on-site work) take? ....months

How would you gauge the impact of the following constraints on overall project performance?

	Constraints	No impact Very high impact
P25.	Ground conditions	0 1 2 3 4 5 6 7 8 9 10
P26.	Weather conditions	0 1 2 3 4 5 6 7 8 9 10
P27.	Government regulations (e.g. planning permit)	0 1 2 3 4 5 6 7 8 9 10

With regard to the location of the project, please indicate the following:

P28. The ease of access to the site

Extremely poor 0 1 2 3 4 5 6 7 8 9 10 Excellent
e.g. city centre e.g. green field

	Remoteness from	Local (within 10 mile radius) Distant (more than 300 miles radius)
P31.	your office	0 1 2 3 4 5 6 7 8 9 10
P29.	client home office	0 1 2 3 4 5 6 7 8 9 10
P30.	architect home office	0 1 2 3 4 5 6 7 8 9 10

P32. How would you gauge the interaction between contractor and architect prior to on site work?

Low 0 1 2 3 4 5 6 7 8 9 10 High

Section 3 - Client attributes and performance criteria

In the following sections, you will be asked questions concerning the client of the 'case project'. Note: You will not be asked to reveal the identification of the company.

C01. What is the nature of client business?

☐ retail ☐ finance ☐ industrial ☐ other, please specify ....

C02. Approximately, what was the annual turnover of the client's company?
☐ up to £ 10 m. ☐ £ 10 to £ 100 m. ☐ £ 100 to £ 500 m. ☐ above £ 500 m.

C03. How many employees did the client have?
☐ less than 20 ☐ 21 to 100 ☐ 101 to 1000 ☐ above 1000

C04. How long has the client company been established? .... years (approx.)

C05. On how many projects has your company worked with this client before? ....projects

C06. How many similar types of project has your client undertaken within the last five years (approx.)? ....projects

C07. Did the client have a separate department or division which dealt with construction? Yes / No (choose)

C08. If so, how would you gauge the capability of that department in handling construction projects?
Low 0 1 2 3 4 5 6 7 8 9 10 High

C09. How would you gauge the client's construction work load when executing the case project?
No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

C10. How would you describe the client's organisational structure when executing the case project?
Simple 0 1 2 3 4 5 6 7 8 9 10 Complex

C11. How would you describe the client's communication channel when executing the case project?
Centralised 0 1 2 3 4 5 6 7 8 9 10 Decentralised

C12. What was the extent of your client and project evaluation prior to contract award?
Minimum evaluation (e.g. only financial consideration) 0 1 2 3 4 5 6 7 8 9 10 Thorough evaluation of all aspects

C13. Have you previously worked with the client's site personnel appointed to this project? Yes / No (choose)

Please score the following attributes of the client on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Client Attributes	**Negative**										**Positive**
C14.	Financial soundness (i.e. stability and status)	0	1	2	3	4	5	6	7	8	9	10
C15.	Experience in the type of case project	0	1	2	3	4	5	6	7	8	9	10
C16.	Experience in the size of case project	0	1	2	3	4	5	6	7	8	9	10
C17.	Experience in geographical location of case project	0	1	2	3	4	5	6	7	8	9	10
C18.	Past performance generally	0	1	2	3	4	5	6	7	8	9	10
C19.	Past performance in achieving project budget	0	1	2	3	4	5	6	7	8	9	10
C20.	Past performance in achieving project schedule	0	1	2	3	4	5	6	7	8	9	10
C21.	Past performance in good quality project	0	1	2	3	4	5	6	7	8	9	10
C22.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0	1	2	3	4	5	6	7	8	9	10
C23.	Project management experience, i.e.project team organisation	0	1	2	3	4	5	6	7	8	9	10
C24.	Project monitoring experience (e.g. monitoring progress)	0	1	2	3	4	5	6	7	8	9	10
C25.	Experience with quality assurance procedures	0	1	2	3	4	5	6	7	8	9	10
C26.	Qualification and experience of client representative	0	1	2	3	4	5	6	7	8	9	10
C27.	Previous working relationship between contractor and client	0	1	2	3	4	5	6	7	8	9	10

In respect of achieving your project objectives for the 'case project' please indicate your levels of satisfaction acquired for each of the following client performance indicators.

Client Performance Criteria	Level of Satisfaction on case project low high
Understanding of Project Requirements	
• Quality of brief, in terms of clarity	0 1 2 3 4 5 6 7 8 9 10
• Quality of brief, in terms of adequacy and appropriateness	0 1 2 3 4 5 6 7 8 9 10
• Understanding of building process	0 1 2 3 4 5 6 7 8 9 10
• Knowing what they want early	0 1 2 3 4 5 6 7 8 9 10
• Clarity of thinking (not changing their mind)	0 1 2 3 4 5 6 7 8 9 10
• Ability to convey what they want	0 1 2 3 4 5 6 7 8 9 10
Finance	
• Adequacy of funding for the project	0 1 2 3 4 5 6 7 8 9 10
• Timeliness of payment	0 1 2 3 4 5 6 7 8 9 10
• Ease of financial approval due to variations	0 1 2 3 4 5 6 7 8 9 10
Decision Making	
• Ability to make rapid and decisive decisions	0 1 2 3 4 5 6 7 8 9 10
• Quality of the decisions	0 1 2 3 4 5 6 7 8 9 10
• Unity (i.e. clear and single voice)	0 1 2 3 4 5 6 7 8 9 10
Management skills	
• Delegation (give lead designer proper level of authority)	0 1 2 3 4 5 6 7 8 9 10
• Organisational skills	0 1 2 3 4 5 6 7 8 9 10
• Performance in pre-planning (early stages pf'mance)	0 1 2 3 4 5 6 7 8 9 10
• Administration	0 1 2 3 4 5 6 7 8 9 10
Support to Contractor / Architect	
• Information support (quality, timely, etc.)	0 1 2 3 4 5 6 7 8 9 10
• Adequacy of time (achievable and realistic timescale)	0 1 2 3 4 5 6 7 8 9 10
• Providing enough resources	0 1 2 3 4 5 6 7 8 9 10
• Monitoring progress / performance	0 1 2 3 4 5 6 7 8 9 10
• Adequate continuous involvement	0 1 2 3 4 5 6 7 8 9 10
• Ability to balance between involvement and interference	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Integrity and honesty	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Commitment to project	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to problems (queries) that arise	0 1 2 3 4 5 6 7 8 9 10
• Understanding architect difficulties	0 1 2 3 4 5 6 7 8 9 10
• Attitude to variations caused by client changes	0 1 2 3 4 5 6 7 8 9 10
• Allowing architect to enjoy projects	0 1 2 3 4 5 6 7 8 9 10
• Appreciation of architecture	0 1 2 3 4 5 6 7 8 9 10
• Ability to encourage attitude of pro-activeness of all	0 1 2 3 4 5 6 7 8 9 10
• Attitude towards advice (respect, open to solutions, flexible, receptiveness towards ideas)	0 1 2 3 4 5 6 7 8 9 10
• General feeling on how enjoyable/ pleasant client	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of client performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the client?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

Section 4 - Architect attributes and performance criteria

In the following sections, you will be asked questions concerning the architect employed on the 'case project'. Note: You will not be asked to reveal the identification of the architect or architect company. If the 'case project' was not design and build, please do your best to answer these questions.

A01. Operationally, what size (in terms of catchment) was the architectural practice?
☐ local ☐ regional ☐ national ☐ international

A02. Approximately, what was the annual fee turnover of the architectural practice?
☐ up to £ 1m. ☐ £ 1to £ 5 m. ☐ £ 5 to £ 50 m. ☐ above £ 50 m.

A03. How many employees did the architectural practice have?
☐ less than 10 ☐ 11 to 50 ☐ 51 to 200 ☐ above 200

A04. How long has the architectural practice been established? .... years (approx.)

A05. On how many projects has your company worked with this architect before? ....projects

A06. If the case project was design and build, what was your method of architect selection?
☐ one to one negotiation ☐ competitive interview ☐ fee tender ☐ other, specify.....................

If the case project was design and build, please indicate the levels of importance of the following architect selection criteria:

	Architect selection criteria	Level of Importance										
		low										extremely high
A07.	Technical ability	0	1	2	3	4	5	6	7	8	9	10
A08.	Past experience / performance	0	1	2	3	4	5	6	7	8	9	10
A09.	Quality and design flair	0	1	2	3	4	5	6	7	8	9	10
A10.	Third party references/ recommendations	0	1	2	3	4	5	6	7	8	9	10
A11.	Fee	0	1	2	3	4	5	6	7	8	9	10
A12.	Reputation	0	1	2	3	4	5	6	7	8	9	10

A13. How would you gauge the extent of architect evaluation prior to engagement?
Minimum evaluation (e.g. only references) 0 1 2 3 4 5 6 7 8 9 10 Thorough evaluation of all aspects

A14. How would you gauge the architect's work load when executing this project?
No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

A15. What was the method of architect payment?
☐ lump sum fee ☐ percentage cost ☐ other, specify.....................

A16. As percentage to total project cost, what was architect design fee? ....%

A17. What influence did you have on appointment of architect's personnel to the project:?
No influence 0 1 2 3 4 5 6 7 8 9 10 Strong influence

A18. Have you previously worked with the project architects appointed to this project? Yes / No (choose)

Please score the following attributes of the architect on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Architect Attributes	Negative										Positive
A19.	Financial soundness (i.e. stability and status)	0	1	2	3	4	5	6	7	8	9	10
A20.	Experience in the type of case project	0	1	2	3	4	5	6	7	8	9	10
A21.	Experience in the size of case project	0	1	2	3	4	5	6	7	8	9	10
A22.	Experience in geographical location of case project	0	1	2	3	4	5	6	7	8	9	10
A23.	References from other clients	0	1	2	3	4	5	6	7	8	9	10
A24.	Past performance in the last project (before case project)	0	1	2	3	4	5	6	7	8	9	10
A25.	Reputation in speed of information delivery	0	1	2	3	4	5	6	7	8	9	10
A26.	Reputation in adherence to budget	0	1	2	3	4	5	6	7	8	9	10
A27.	Reputation in quality of design	0	1	2	3	4	5	6	7	8	9	10
A28.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0	1	2	3	4	5	6	7	8	9	10
A29.	Reputation in commercial attitude (e.g. additional fee)	0	1	2	3	4	5	6	7	8	9	10
A30.	Qualification and experience of director / principal	0	1	2	3	4	5	6	7	8	9	10
A31.	Qualification and experience of project architect	0	1	2	3	4	5	6	7	8	9	10
A32.	Quality assurance system	0	1	2	3	4	5	6	7	8	9	10
A33.	Previous working relationship between contractor and architect	0	1	2	3	4	5	6	7	8	9	10

In respect of achieving your project objectives for the 'case project', please indicate your levels of satisfaction acquired for each of the following architect performance indicators.

Architect Performance Criteria	Level of Satisfaction on case project low high
Pre-construction Stage	
• First interview and design presentation (visibility)	0 1 2 3 4 5 6 7 8 9 10
• Ability to develop brief and resolution of the brief	0 1 2 3 4 5 6 7 8 9 10
• Method statement (ability to explain how the project will be handled)	0 1 2 3 4 5 6 7 8 9 10
• Understanding of client culture (e.g. nature of client company) to assess the real need	0 1 2 3 4 5 6 7 8 9 10
Quality of Design	
• Design suitability to solution (relevancy, practicallity)	0 1 2 3 4 5 6 7 8 9 10
• Design buildability / constructability	0 1 2 3 4 5 6 7 8 9 10
• Design flair or aesthetic sense and innovation	0 1 2 3 4 5 6 7 8 9 10
• Design to provide value for money	0 1 2 3 4 5 6 7 8 9 10
• Design to incorporate health and safety issues	0 1 2 3 4 5 6 7 8 9 10
• Design concern for environmental issues	0 1 2 3 4 5 6 7 8 9 10
• Design simplicity for operations and maintenance	0 1 2 3 4 5 6 7 8 9 10
• Design adaptability or sustainability	0 1 2 3 4 5 6 7 8 9 10
• Quality of detail drawing and specifications (e.g. accuracy, completeness)	0 1 2 3 4 5 6 7 8 9 10
Management Skill	
• Design management and supervision	0 1 2 3 4 5 6 7 8 9 10
• Ability to manage the construction process (as contract administrator)	0 1 2 3 4 5 6 7 8 9 10
• Coordination between team members or consultants	0 1 2 3 4 5 6 7 8 9 10

Architect Performance Criteria	**Level of Satisfaction on case project** low high
• Company organisational skills & org. structure	0 1 2 3 4 5 6 7 8 9 10
• Management of resources (commitment of resources)	0 1 2 3 4 5 6 7 8 9 10
Technical Skill	
• Practical construction knowledge	0 1 2 3 4 5 6 7 8 9 10
• Suitability and quality of major building components or products selected	0 1 2 3 4 5 6 7 8 9 10
• Incorporation of mechanical and electrical services into the structure	0 1 2 3 4 5 6 7 8 9 10
• Understanding and compliance with legislation and statutory requirements (CDM, fire regl., etc.)	0 1 2 3 4 5 6 7 8 9 10
Quality of Services	
• Effective handling of complaints	0 1 2 3 4 5 6 7 8 9 10
• Telephone inquiries and correspondence handled courteously and adequately	0 1 2 3 4 5 6 7 8 9 10
• Speed and reliability of service (e.g. redrawing)	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to client queries (flexibility)	0 1 2 3 4 5 6 7 8 9 10
• Ability to make rapid and decisive decisions	0 1 2 3 4 5 6 7 8 9 10
• Commitment of key persons (active & continuous)	0 1 2 3 4 5 6 7 8 9 10
• Willingness to draft the documents / drawings, not only do conceptual work	0 1 2 3 4 5 6 7 8 9 10
• Follow up (e.g. defects) or services offered after project completion	0 1 2 3 4 5 6 7 8 9 10
• Corporate hospitality	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Integrity	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Keep the client informed (willingness to involve cl.)	0 1 2 3 4 5 6 7 8 9 10
• Communication with other coalition members	0 1 2 3 4 5 6 7 8 9 10
• Commercial attitude (e.g. additional fees)	0 1 2 3 4 5 6 7 8 9 10
• Pro-active to know site problems (e.g. by regular site visit)	0 1 2 3 4 5 6 7 8 9 10
• Attitude in dealing with client and contractor	0 1 2 3 4 5 6 7 8 9 10
• Avoidance of design changes	0 1 2 3 4 5 6 7 8 9 10
• Listen to what client wants (customer focus)	0 1 2 3 4 5 6 7 8 9 10
• Responsibility for their decision (understand the cost of their recommendations)	0 1 2 3 4 5 6 7 8 9 10
Main Criteria	
• General quality of building (both functionality and aesthetics)	0 1 2 3 4 5 6 7 8 9 10
• Compliance with information required schedule	0 1 2 3 4 5 6 7 8 9 10
• Compliance with requirements	0 1 2 3 4 5 6 7 8 9 10
• Compliance to budget	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of architect performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the architect?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

This is the end of questionnaire. Thank you very much for your help.

Appendix C:

Questionnaires for Second Stage Survey

Performance and Satisfaction Research
(Client Questionnaire)

This questionnaire represents part of a research programme aimed at developing a tool to predict levels of performance and satisfaction for the three main participants in the construction project coalition, i.e. clients, contractors and architects. This tool will enable members of the project coalition to foresee problems and forecast performance before project commencement. For example, clients of the construction industry will be able to predict the performance of their chosen contractors and architects allowing appropriate corrective actions to be implemented, e.g. to mitigate under-performing contractors and architects so that overall project performance can be improved.

We would like you to consider a recent (i.e. last 2 years) building project that you have procured from the construction industry (referred to hereafter as the 'case project'). Preferably, but not exclusively, this 'case project' should be located in the UK and have been procured using the traditional route or a form of partnering. Here, the traditional procurement route is defined as the method of procuring a building in which professionals and contractor are independently employed by the client using separate contracts, whereas partnering is where all participants involved are engaged in long term relationships, which may involve the construction of a project or a series of projects for the 'agreed common objectives', for the purpose of continuous improvements. <u>You will need to relate all your responses to the questions in this questionnaire to this one case project</u>. Due to the nature of the information requested, we have deliberately designed the questionnaire to avoid identifying projects, naming other participants, etc. The first section of the questionnaire seeks information concerning you and your company. The second section seeks to categorise the characteristics of the case project. The final sections ask you to indicate the attributes and satisfaction levels derived from key participant performance criteria, again for the case project. Please note, if you have other attributes, characteristics or criteria, please feel free to comment and add. <u>All the information provided will be held in strict confidence and used for research purposes only</u>. A SAE is enclosed for your convenience.

Many of the questions presented require you to indicate your response on a scale. For example: How would you gauge the complexity of the case project:

Easy Highly complex

0 1 2 3 4 5 6 7 8 9 10

If you considered the case project to be, say somewhat complicated, you may rate the complexity a value of 6, and therefore circle this value to indicate your response as shown.

If you would like further information or have any queries, please do not hesitate to contact me. If you would like to receive a summary of the research findings, please tick here □.

Thank you for your kind attention and assistance.

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Section 1 - Your details

Respondent Details

Your name : .... Name of Employer : ....

Your position : .... Department : ....

Contact address : ....

Telephone : .... Fax : ....E-mail: ....

Respondent Attributes

R02. How long have you been involved in building construction projects? ....years

R04. How many similar projects (to the 'case project') have you been involved in the last five years? ....projects

How would you gauge your overall satisfaction of all projects you have undertaken in terms of the following:

	Satisfaction in terms of	Dissatisfied ... Satisfied
R07.	Architect performance	0 1 2 3 4 5 6 7 8 9 10
R08.	Contractor performance	0 1 2 3 4 5 6 7 8 9 10

Please indicate your general perception on the following statements concerning architects in the UK construction industry

	Perception of architects	False ... True
R16.	Don't listen to views of other coalition members	0 1 2 3 4 5 6 7 8 9 10
R17.	More interested in design aesthetics than buildability	0 1 2 3 4 5 6 7 8 9 10
R18.	Unable to meet deadlines (late information delivery)	0 1 2 3 4 5 6 7 8 9 10
R19.	Poor management skills	0 1 2 3 4 5 6 7 8 9 10
R20.	Poor technical skills	0 1 2 3 4 5 6 7 8 9 10
R21.	Unreliable	0 1 2 3 4 5 6 7 8 9 10
R22.	Disorganised	0 1 2 3 4 5 6 7 8 9 10

Please indicate your general perception on the following statements concerning contractors in the UK construction industry

	Perception of contractors	False ... True
R24.	Too willing to 'build claims'	0 1 2 3 4 5 6 7 8 9 10
R25.	Never finish projects on time	0 1 2 3 4 5 6 7 8 9 10
R26.	Contractual	0 1 2 3 4 5 6 7 8 9 10
R27.	Wasteful / untidy	0 1 2 3 4 5 6 7 8 9 10
R28.	Unproductive / inefficient	0 1 2 3 4 5 6 7 8 9 10
R29.	Slow to adopt new technology / innovations	0 1 2 3 4 5 6 7 8 9 10

Section 2 - 'Case project' attributes

Please relate all following responses to just one recent 'case project' as described previously.

P01. Type of project:
□ new building □ refurbishment □ extension to existing premises □ other, please specify ………

P02. Type of building:
□ office □ retail □ residential …… □ industrial …… □ public …… □ other, please specify ……

P03. How many storeys? ……….storeys

P06. What procurement route did you adopt on this project?
□ traditional □ design and build □ partnering □ other, specify…………..

P09. What was the planned duration of the project? ………..months

P10. Did the project overrun? Yes / No (choose)
P11. If so, by how much time? ………… days/weeks/months (choose)

P12. What was the tender sum for the project? £ ……………………

P13. Did the project finish overbudget? Yes / No (choose)
P14. If so, by how much money? £ ………………

P15. How would you gauge the severity (<u>in terms of value</u>) of variations on this case project?
Least severe 0 1 2 3 4 5 6 7 8 9 10 Most severe

With regard to the source or cause of these variations, how would you assess the contribution of the following parties?

	Cause of Variations	Never										Always
P17.	Client	0	1	2	3	4	5	6	7	8	9	10
P18.	Architect	0	1	2	3	4	5	6	7	8	9	10
P19.	Contractor	0	1	2	3	4	5	6	7	8	9	10

P21. How would you gauge the level of design complexity on this project?
Easy /typical 0 1 2 3 4 5 6 7 8 9 10 Extremely complex

P23. In percentage terms, at the commencement of construction works on site, how much of the design had been completed? ……….%

How would you gauge the impact of the following constraints on overall project performance?

	Constraints	No impact										Very high impact
P25.	Ground conditions	0	1	2	3	4	5	6	7	8	9	10
P26.	Weather conditions	0	1	2	3	4	5	6	7	8	9	10

With regard to the location of the project, please indicate the following:

P28. The ease of access to the site

Extremely poor 0 1 2 3 4 5 6 7 8 9 10 Excellent
e.g. city centre e.g. green field

	Remoteness from	Local (within 10 mile radius) — Distant (more than 300 miles radius)
P30.	architect home office	0 1 2 3 4 5 6 7 8 9 10

P32. How would you gauge the interaction between contractor and architect prior to on site work?

Low 0 1 2 3 4 5 6 7 8 9 10 High

Section 3 - Contractor attributes and performance criteria

In the following sections, you will be asked questions concerning the contractor employed on the 'case project'. Note: You will not be asked to reveal the identification of the company.

O06. What was your method of contractor selection?

☐ competitive tendering ☐ two stage competitive tendering ☐ negotiation ☐ other, specify................

O13. How would you gauge the extent of contractor evaluation prior to contract award?

Minimum evaluation 0 1 2 3 4 5 6 7 8 9 10 Thorough evaluation of
(e.g. only references) all aspects

O14. How would you gauge the contractor's work load when executing the case project?

No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

O15. What was your method of contractor payment?

☐ lump sum ☐ unit price ☐ cost reimbursement ☐ other, specify.............................

O19. Have you previously worked with the contractor's site personnel appointed to this project? Yes / No (choose)

Please score the following attributes of the contractor on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Contractor Attributes	Negative										Positive
O20.	Financial soundness (i.e. stability and status)	0	1	2	3	4	5	6	7	8	9	10
O21.	Experience in the type of case project	0	1	2	3	4	5	6	7	8	9	10
O22.	Experience in the size of case project	0	1	2	3	4	5	6	7	8	9	10
O24.	References from other clients and consultants	0	1	2	3	4	5	6	7	8	9	10
O25.	Past performance in the last project (before case project)	0	1	2	3	4	5	6	7	8	9	10
O26.	Reputation in on time completion	0	1	2	3	4	5	6	7	8	9	10
O27.	Reputation in on budget completion	0	1	2	3	4	5	6	7	8	9	10
O28.	Reputation in product quality / workmanship	0	1	2	3	4	5	6	7	8	9	10
O29.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0	1	2	3	4	5	6	7	8	9	10
O30.	Reputation in claims (*note:* **Positive** *means not claim conscious*)	0	1	2	3	4	5	6	7	8	9	10
O31.	Qualification and experience of director	0	1	2	3	4	5	6	7	8	9	10
O32.	Qualification and experience of site personnel /P.M.	0	1	2	3	4	5	6	7	8	9	10
O33.	Health and safety past performance and policy	0	1	2	3	4	5	6	7	8	9	10
O34.	Formal training regime for site personnel	0	1	2	3	4	5	6	7	8	9	10
O35.	Quality control policy	0	1	2	3	4	5	6	7	8	9	10
O36.	Industrial relation: knowledge of local subs and suppliers	0	1	2	3	4	5	6	7	8	9	10
O37.	Industrial relation: knowledge of local labour	0	1	2	3	4	5	6	7	8	9	10
O39.	Previous working relationship between client and contractor	0	1	2	3	4	5	6	7	8	9	10

In respect of achieving your project objectives for the 'case project' please indicate your levels of satisfaction acquired for each of the following contractor performance indicators.

Contractor Performance Criteria	Level of Satisfaction on case project low — high
Pre-construction Stage	
• First interview and presentation	0 1 2 3 4 5 6 7 8 9 10
• Ability and willingness to help develop brief	0 1 2 3 4 5 6 7 8 9 10
• Contribution to design and buildability of project	0 1 2 3 4 5 6 7 8 9 10
• Plan of work and method statement	0 1 2 3 4 5 6 7 8 9 10
• Understanding of contract and specifications	0 1 2 3 4 5 6 7 8 9 10
Construction Stage *Site management*	
• Site supervision and control	0 1 2 3 4 5 6 7 8 9 10
• Site organisation, tidiness and cleanliness	0 1 2 3 4 5 6 7 8 9 10
• Ability to plan and programme properly	0 1 2 3 4 5 6 7 8 9 10
• Health and safety performance / management	0 1 2 3 4 5 6 7 8 9 10
• Compliance to regulations (CDM, etc.)	0 1 2 3 4 5 6 7 8 9 10
Resource management	
• Material management	0 1 2 3 4 5 6 7 8 9 10
• Man power management (sufficient quantity and quality of craftsmen)	0 1 2 3 4 5 6 7 8 9 10
• Equipment and plant management	0 1 2 3 4 5 6 7 8 9 10
• Managt. and co-ord. of subcontractors and suppliers	0 1 2 3 4 5 6 7 8 9 10
• Payment to subcontractors and suppliers (on time)	0 1 2 3 4 5 6 7 8 9 10
• Strength of contractor site team (i.e. quantity)	0 1 2 3 4 5 6 7 8 9 10
• Concern/awareness for environmental issues	0 1 2 3 4 5 6 7 8 9 10

Contractor Performance Criteria	Level of Satisfaction on case project low high
Site personnel	
• Cooperation with client (i.e. client representative)	0 1 2 3 4 5 6 7 8 9 10
• Individual performance and ability	0 1 2 3 4 5 6 7 8 9 10
• Project manager performance and adequacy of authority	0 1 2 3 4 5 6 7 8 9 10
• Site manner (i.e. no loud noises and swearing)	0 1 2 3 4 5 6 7 8 9 10
Variations and drawings	
• Processing variations (e.g. speed, flexibility)	0 1 2 3 4 5 6 7 8 9 10
• Preparation of shop drawings and as-built drawings	0 1 2 3 4 5 6 7 8 9 10
• Contribution to development of design drawings	0 1 2 3 4 5 6 7 8 9 10
Completion Stage & Ease of Delivery	
• Completion of defects	0 1 2 3 4 5 6 7 8 9 10
• Smoothness of operation and hand-over	0 1 2 3 4 5 6 7 8 9 10
• Quality of hand-over document (O&M manual, H&S)	0 1 2 3 4 5 6 7 8 9 10
• Ease / speed of settlement of final account	0 1 2 3 4 5 6 7 8 9 10
• Ease of delivery (general feeling on how things went)	0 1 2 3 4 5 6 7 8 9 10
Principal	
• Adherence to schedule (time performance)	0 1 2 3 4 5 6 7 8 9 10
• Adherence to budget (cost performance)	0 1 2 3 4 5 6 7 8 9 10
• Quality of construction and workmanship	0 1 2 3 4 5 6 7 8 9 10
Quality of Service	
• Handling of complaints (effectiveness)	0 1 2 3 4 5 6 7 8 9 10
• Telephone inquiries and correspondence handled courteously and adequately	0 1 2 3 4 5 6 7 8 9 10
• Speed and reliability of service	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to client	0 1 2 3 4 5 6 7 8 9 10
• Ability to make rapid decisions	0 1 2 3 4 5 6 7 8 9 10
• Commitment of key person (active & continuous)	0 1 2 3 4 5 6 7 8 9 10
• Corporate hospitality	0 1 2 3 4 5 6 7 8 9 10
• Administration	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Honesty and integrity	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Customer focus / proactive to understand client	0 1 2 3 4 5 6 7 8 9 10
• Keep the client informed	0 1 2 3 4 5 6 7 8 9 10
• Communication (to coalition member & site person)	0 1 2 3 4 5 6 7 8 9 10
• Pro-active attitude toward problems	0 1 2 3 4 5 6 7 8 9 10
• Avoidance of claims (i.e. not claims conscious)	0 1 2 3 4 5 6 7 8 9 10
• Responsibility for their decision (understand the cost of his recommendation)	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of contractor performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the contractor?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

Section 4 - Architect attributes and performance criteria

In the following sections, you will be asked questions concerning the architect employed on the 'case project'. Note: You will not be asked to reveal the identification of the architect or architect company. If the 'case project' was design and build, please do your best to answer these questions, by assessing the provision of these services by the contractor.

A03. How many employees did the architectural practice have?

☐ less than 10 ☐ 11 to 50 ☐ 51 to 200 ☐ above 200

A05. On how many projects has your company worked with this architect before? ....projects

A14. How would you gauge the architect's work load when executing this project?

No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

A18. Have you previously worked with the project architects appointed to this project? Yes / No (choose)

Please score the following attributes of the architect on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Architect Attributes	Negative Positive
A19.	Financial soundness (i.e. stability and status)	0 1 2 3 4 5 6 7 8 9 10
A20.	Experience in the type of case project	0 1 2 3 4 5 6 7 8 9 10
A21.	Experience in the size of case project	0 1 2 3 4 5 6 7 8 9 10
A24.	Past performance in the last project (before case project)	0 1 2 3 4 5 6 7 8 9 10
A25.	Reputation in speed of information delivery	0 1 2 3 4 5 6 7 8 9 10
A26.	Reputation in adherence to budget	0 1 2 3 4 5 6 7 8 9 10
A27.	Reputation in quality of design	0 1 2 3 4 5 6 7 8 9 10
A28.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0 1 2 3 4 5 6 7 8 9 10
A30.	Qualification and experience of director / principal	0 1 2 3 4 5 6 7 8 9 10
A31.	Qualification and experience of project architect	0 1 2 3 4 5 6 7 8 9 10
A32.	Quality assurance system	0 1 2 3 4 5 6 7 8 9 10
A33.	Previous working relationship between client and architect	0 1 2 3 4 5 6 7 8 9 10

In respect of achieving your project objectives for the 'case project', please indicate your levels of satisfaction acquired for each of the following architect performance indicators.

Architect Performance Criteria	Level of Satisfaction on case project low high
Pre-construction Stage	
• First interview and design presentation (visibility)	0 1 2 3 4 5 6 7 8 9 10
• Ability to develop brief and resolution of the brief	0 1 2 3 4 5 6 7 8 9 10
• Method statement (ability to explain how the project will be handled)	0 1 2 3 4 5 6 7 8 9 10
• Understanding of client culture (e.g. nature of client company) to assess the real need	0 1 2 3 4 5 6 7 8 9 10
Quality of Design	
• Design suitability to solution (relevancy, practicallity)	0 1 2 3 4 5 6 7 8 9 10
• Design buildability / constructability	0 1 2 3 4 5 6 7 8 9 10
• Design flair or aesthetic sense and innovation	0 1 2 3 4 5 6 7 8 9 10

Architect Performance Criteria	Level of Satisfaction on case project low high
• Design to provide value for money	0 1 2 3 4 5 6 7 8 9 10
• Design to incorporate health and safety issues	0 1 2 3 4 5 6 7 8 9 10
• Design concern for environmental issues	0 1 2 3 4 5 6 7 8 9 10
• Design simplicity for operations and maintenance	0 1 2 3 4 5 6 7 8 9 10
• Design adaptability or sustainability	0 1 2 3 4 5 6 7 8 9 10
• Quality of detail drawing and specifications (e.g. accuracy, completeness)	0 1 2 3 4 5 6 7 8 9 10
Management Skill	
• Design management and supervision	0 1 2 3 4 5 6 7 8 9 10
• Ability to manage the construction process (as contract administrator)	0 1 2 3 4 5 6 7 8 9 10
• Coordination between team members or consultants	0 1 2 3 4 5 6 7 8 9 10
• Company organisational skills & organizational structure	0 1 2 3 4 5 6 7 8 9 10
• Management of resources (commitment of resources)	0 1 2 3 4 5 6 7 8 9 10
Technical Skill	
• Practical construction knowledge	0 1 2 3 4 5 6 7 8 9 10
• Suitability and quality of major building components or products selected	0 1 2 3 4 5 6 7 8 9 10
• Incorporation of mechanical and electrical services into the structure	0 1 2 3 4 5 6 7 8 9 10
• Understanding and compliance with legislation and statutory requirements (CDM, fire regulation, etc.)	0 1 2 3 4 5 6 7 8 9 10
Quality of Services	
• Effective handling of complaints	0 1 2 3 4 5 6 7 8 9 10
• Telephone inquiries and correspondence handled courteously and adequately	0 1 2 3 4 5 6 7 8 9 10
• Speed and reliability of service (e.g. redrawing)	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to client queries (flexibility)	0 1 2 3 4 5 6 7 8 9 10
• Ability to make rapid and decisive decisions	0 1 2 3 4 5 6 7 8 9 10
• Commitment of key persons (active & continuous)	0 1 2 3 4 5 6 7 8 9 10
• Willingness to draft the documents / drawings, not only do conceptual work	0 1 2 3 4 5 6 7 8 9 10
• Follow up (e.g. defects) or services offered after project completion	0 1 2 3 4 5 6 7 8 9 10
• Corporate hospitality	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Integrity	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Keep the client informed (willingness to involve client)	0 1 2 3 4 5 6 7 8 9 10
• Communication with other coalition members	0 1 2 3 4 5 6 7 8 9 10
• Commercial attitude (e.g. additional fees)	0 1 2 3 4 5 6 7 8 9 10
• Pro-active to know site problems (e.g. by regular site visit)	0 1 2 3 4 5 6 7 8 9 10
• Attitude in dealing with client and contractor	0 1 2 3 4 5 6 7 8 9 10
• Avoidance of design changes	0 1 2 3 4 5 6 7 8 9 10
• Listen to what client wants (customer focus)	0 1 2 3 4 5 6 7 8 9 10
• Responsibility for their decision (understand the cost of their recommendations)	0 1 2 3 4 5 6 7 8 9 10
Main Criteria	
• General quality of building (both functionality and aesthetics)	0 1 2 3 4 5 6 7 8 9 10
• Compliance with information required schedule	0 1 2 3 4 5 6 7 8 9 10
• Compliance with requirements	0 1 2 3 4 5 6 7 8 9 10
• Compliance to budget	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of architect performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the architect?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

This is the end of questionnaire. Thank you very much for your help.

Performance and Satisfaction Research.
(Architect Questionnaire)

This questionnaire represents part of a research programme aimed at developing a tool to predict levels of performance and satisfaction for the three main participants in the construction project coalition, i.e. clients, contractors and architects. This tool will enable members of the project coalition to foresee problems and forecast performance before project commencement. For example, architects will be able to predict the performance of their clients and contractors allowing appropriate corrective actions to be implemented, e.g. to mitigate under-performing clients and contractors so that overall project performance can be improved.

We would like you to consider a recent (i.e. last 2 years) building project that your company designed (referred to hereafter as the 'case project'). Preferably, but not exclusively, this 'case project' should be located in the UK and have been procured using the traditional route or a form of partnering. You will need to relate all your responses to the questions in this questionnaire to this one case project. Due to the nature of the information requested, we have deliberately designed the questionnaire to avoid identifying projects, naming other participants, etc. The first section of the questionnaire seeks information concerning you and your company. The second section seeks to categorise the characteristics of the case project. The final sections ask you to indicate the attributes and satisfaction levels derived from key participant performance criteria, again for the case project. Please note, if you have other attributes, characteristics or criteria, please feel free to comment and add. All the information provided will be held in strict confidence and used for research purposes only. A SAE is enclosed for your convenience.

Many of the questions presented require you to indicate your response on a scale. For example: How would you gauge the complexity of the case project:

Easy Highly complex

0 1 2 3 4 5 6 7 8 9 10

If you considered the case project to be, say somewhat complicated, you may rate the complexity a value of 6, and therefore circle this value to indicate your response as shown.

If you would like further information or have any queries, please do not hesitate to contact me. If you would like to receive a summary of the research findings, please tick here □.

Thank you for your kind attention and assistance.

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Section 1 - Your details

Respondent Details

Your name : .... Name of Employer : ....

Your position : .... Department : ....

Contact address : ....

Telephone : .... Fax : ....E-mail: ....

Respondent Attributes

R04. How many similar projects (to the 'case project') have you been involved in the last five years? ....projects

How would you gauge your overall satisfaction of all projects you have undertaken in terms of the following:

	Satisfaction in terms of	Dissatisfied Satisfied
R06.	Client performance	0 1 2 3 4 5 6 7 8 9 10
R08.	Contractor performance	0 1 2 3 4 5 6 7 8 9 10

Please indicate your general perception on the following statements concerning clients in the UK construction industry

	Perception of clients	False True
R09.	Do not know what they want	0 1 2 3 4 5 6 7 8 9 10
R10.	Always changing their mind	0 1 2 3 4 5 6 7 8 9 10
R14.	Always want to minimise cost without considering quality	0 1 2 3 4 5 6 7 8 9 10
R15.	Tend to be influenced by their initial advisors (e.g. QS, architect)	0 1 2 3 4 5 6 7 8 9 10

Please indicate your general perception on the following statements concerning contractors in the UK construction industry

	Perception of contractors	False True
R24.	Too willing to 'build claims'	0 1 2 3 4 5 6 7 8 9 10
R25.	Never finish projects on time	0 1 2 3 4 5 6 7 8 9 10
R26.	Contractual	0 1 2 3 4 5 6 7 8 9 10
R27.	Wasteful / untidy	0 1 2 3 4 5 6 7 8 9 10
R28.	Unproductive / inefficient	0 1 2 3 4 5 6 7 8 9 10
R29.	Slow to adopt new technology / innovations	0 1 2 3 4 5 6 7 8 9 10

Company Attributes

F03. How many people are employed by your company? ....employees

Section 2 - 'Case project' attributes

Please relate all following responses to just one recent 'case project' as described previously.

P01. Type of project:
☐ new building ☐ refurbishment ☐ extension to existing premises ☐ other, please specify ....

P02. Type of building:
☐ office ☐ retail ☐ residential ..... ☐ industrial ..... ☐ public .... ☐ other, please specify ....

P03. How many storeys? ....storeys.

P06. What procurement route did you adopt on this project?
☐ traditional ☐ design and build ☐ partnering ☐ other, specify............

P09. What was the planned duration of the project? ....months

P10. Did the project overrun? Yes / No (choose)
P11. If so, by how much time? .... days/weeks/months (choose)

P12. What was the tender sum for the project? £ ....

P13. Did the project finish overbudget? Yes / No (choose)
P14. If so, by how much money? £ ....

P15. How would you gauge the severity (<u>in terms of value</u>) of variations on this case project?
Least severe 0 1 2 3 4 5 6 7 8 9 10 Most severe

With regard to the source or cause of these variations, how would you assess the contribution of the following parties?

	Cause of Variations	Never Always
P18.	Architect	0 1 2 3 4 5 6 7 8 9 10
P19.	Contractor	0 1 2 3 4 5 6 7 8 9 10

P21. How would you gauge the level of design complexity on this project?
Easy /typical 0 1 2 3 4 5 6 7 8 9 10 Extremely complex

P23. In percentage terms, at the commencement of construction works on site, how much of the design had been completed? ....%

How would you gauge the impact of the following constraints on overall project performance?

	Constraints	No impact Very high impact
P25.	Ground conditions	0 1 2 3 4 5 6 7 8 9 10
P26.	Weather conditions	0 1 2 3 4 5 6 7 8 9 10
P27.	Government regulations (e.g. planning permit)	0 1 2 3 4 5 6 7 8 9 10

With regard to the location of the project, please indicate the following:

P28. The ease of access to the site

Extremely poor 0 1 2 3 4 5 6 7 8 9 10 Excellent
e.g. city centre e.g. green field

	Remoteness from	Local (within 10 mile radius) — Distant (more than 300 miles radius)
P29.	client home office	0 1 2 3 4 5 6 7 8 9 10

P32. How would you gauge the interaction between contractor and architect prior to on site work?

Low 0 1 2 3 4 5 6 7 8 9 10 High

Section 3 - Contractor attributes and performance criteria

In the following sections, you will be asked questions concerning the contractor employed on the 'case project'. Note: You will not be asked to reveal the identification of the company.

O06. What was the method of contractor selection?

☐ competitive tendering ☐ two stage competitive tendering ☐ negotiation ☐ other, specify...........

O13. How would you gauge the extent of contractor evaluation prior to contract award?

Minimum evaluation 0 1 2 3 4 5 6 7 8 9 10 Thorough evaluation of
(e.g. only references) all aspects

O14. How would you gauge the contractor's work load when executing the case project?

No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

O15. What was the method of contractor payment?

☐ lump sum ☐ unit price ☐ cost reimbursement ☐ other, specify.............................

O19. Have you previously worked with the contractor's site personnel appointed to this project? Yes / No (choose)

Please score the following attributes of the contractor on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Contractor Attributes	Negative Positive
O20.	Financial soundness (i.e. stability and status)	0 1 2 3 4 5 6 7 8 9 10
O21.	Experience in the type of case project	0 1 2 3 4 5 6 7 8 9 10
O22.	Experience in the size of case project	0 1 2 3 4 5 6 7 8 9 10
O24.	References from other clients and consultants	0 1 2 3 4 5 6 7 8 9 10
O25.	Past performance in the last project (before case project)	0 1 2 3 4 5 6 7 8 9 10
O26.	Reputation in on time completion	0 1 2 3 4 5 6 7 8 9 10
O27.	Reputation in on budget completion	0 1 2 3 4 5 6 7 8 9 10
O28.	Reputation in product quality / workmanship	0 1 2 3 4 5 6 7 8 9 10
O29.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0 1 2 3 4 5 6 7 8 9 10
O30.	Reputation in claims (*note:* **Positive** *means not claim conscious*)	0 1 2 3 4 5 6 7 8 9 10
O31.	Qualification and experience of director	0 1 2 3 4 5 6 7 8 9 10
O32.	Qualification and experience of site personnel /P.M.	0 1 2 3 4 5 6 7 8 9 10
O33.	Health and safety past performance and policy	0 1 2 3 4 5 6 7 8 9 10
O34.	Formal training regime for site personnel	0 1 2 3 4 5 6 7 8 9 10
O35.	Quality control policy	0 1 2 3 4 5 6 7 8 9 10
O36.	Industrial relation: knowledge of local subs and suppliers	0 1 2 3 4 5 6 7 8 9 10
O37.	Industrial relation: knowledge of local labour	0 1 2 3 4 5 6 7 8 9 10
O39.	Previous working relationship between architect and contractor	0 1 2 3 4 5 6 7 8 9 10

In respect of achieving your project objectives for the 'case project' please indicate your levels of satisfaction acquired for each of the following contractor performance indicators.

Contractor Performance Criteria	Level of Satisfaction on case project low high
Pre-construction Stage	
• First interview and presentation	0 1 2 3 4 5 6 7 8 9 10
• Ability and willingness to help develop brief	0 1 2 3 4 5 6 7 8 9 10
• Contribution to design and buildability of project	0 1 2 3 4 5 6 7 8 9 10
• Plan of work and method statement	0 1 2 3 4 5 6 7 8 9 10
• Understanding of contract and specifications	0 1 2 3 4 5 6 7 8 9 10
Construction Stage *Site management*	
• Site supervision and control	0 1 2 3 4 5 6 7 8 9 10
• Site organisation, tidiness and cleanliness	0 1 2 3 4 5 6 7 8 9 10
• Ability to plan and programme properly	0 1 2 3 4 5 6 7 8 9 10
• Health and safety performance / management	0 1 2 3 4 5 6 7 8 9 10
• Compliance to regulations (CDM, etc.)	0 1 2 3 4 5 6 7 8 9 10
Resource management	
• Material management	0 1 2 3 4 5 6 7 8 9 10
• Man power management (sufficient quantity and quality of craftsmen)	0 1 2 3 4 5 6 7 8 9 10
• Equipment and plant management	0 1 2 3 4 5 6 7 8 9 10
• Managt. and co-ord. of subcontractors and suppliers	0 1 2 3 4 5 6 7 8 9 10
• Payment to subcontractors and suppliers (on time)	0 1 2 3 4 5 6 7 8 9 10
• Strength of contractor site team (i.e. quantity)	0 1 2 3 4 5 6 7 8 9 10
• Concern/awareness for environmental issues	0 1 2 3 4 5 6 7 8 9 10

Contractor Performance Criteria	Level of Satisfaction on case project low high
Site personnel	
• Cooperation with client (i.e. client representative)	0 1 2 3 4 5 6 7 8 9 10
• Individual performance and ability	0 1 2 3 4 5 6 7 8 9 10
• Project manager performance and adequacy of authority	0 1 2 3 4 5 6 7 8 9 10
• Site manner (i.e. no loud noises and swearing)	0 1 2 3 4 5 6 7 8 9 10
Variations and drawings	
• Processing variations (e.g. speed, flexibility)	0 1 2 3 4 5 6 7 8 9 10
• Preparation of shop drawings and as-built drawings	0 1 2 3 4 5 6 7 8 9 10
• Contribution to development of design drawings	0 1 2 3 4 5 6 7 8 9 10
Completion Stage & Ease of Delivery	
• Completion of defects	0 1 2 3 4 5 6 7 8 9 10
• Smoothness of operation and hand-over	0 1 2 3 4 5 6 7 8 9 10
• Quality of hand-over document (O&M manual, H&S)	0 1 2 3 4 5 6 7 8 9 10
• Ease / speed of settlement of final account	0 1 2 3 4 5 6 7 8 9 10
• Ease of delivery (general feeling on how things went)	0 1 2 3 4 5 6 7 8 9 10
Principal	
• Adherence to schedule (time performance)	0 1 2 3 4 5 6 7 8 9 10
• Adherence to budget (cost performance)	0 1 2 3 4 5 6 7 8 9 10
• Quality of construction and workmanship	0 1 2 3 4 5 6 7 8 9 10
Quality of Service	
• Handling of complaints (effectiveness)	0 1 2 3 4 5 6 7 8 9 10
• Telephone inquiries and correspondence handled courteously and adequately	0 1 2 3 4 5 6 7 8 9 10
• Speed and reliability of service	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to architects' queries	0 1 2 3 4 5 6 7 8 9 10
• Ability to make rapid decisions	0 1 2 3 4 5 6 7 8 9 10
• Commitment of key person (active & continuous)	0 1 2 3 4 5 6 7 8 9 10
• Corporate hospitality	0 1 2 3 4 5 6 7 8 9 10
• Administration	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Honesty and integrity	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Customer focus / proactive to understand architect	0 1 2 3 4 5 6 7 8 9 10
• Keep the architect informed	0 1 2 3 4 5 6 7 8 9 10
• Communication (to coalition member & site person)	0 1 2 3 4 5 6 7 8 9 10
• Pro-active attitude toward problems	0 1 2 3 4 5 6 7 8 9 10
• Avoidance of claims (i.e. not claims conscious)	0 1 2 3 4 5 6 7 8 9 10
• Responsibility for their decision (understand the cost of his recommendation)	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of contractor performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the contractor?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

Section 4 - Client attributes and performance criteria

In the following sections, you will be asked questions concerning the client of the 'case project'. Note: You will not be asked to reveal the identification of the company. If the 'case project' was design and build, please do your best to answer these questions.

C01. What is the nature of client business?
☐ retail ☐ finance ☐ industrial ☐ other, please specify ....

C05. On how many projects has your company worked with this client before? ....projects

C06. How many similar types of project has your client undertaken within the last five years (approx.)? ....projects

C07. Did the client have a separate department or division which dealt with construction? Yes / No (choose)

C08. If so, how would you gauge the capability of that department in handling construction projects?
Low 0 1 2 3 4 5 6 7 8 9 10 High

C09. How would you gauge the client's construction work load when executing the case project?
No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

C10. How would you describe the client's organisational structure when executing the case project?
Simple 0 1 2 3 4 5 6 7 8 9 10 Complex

C11. How would you describe the client's communication channel when executing the case project?
Centralised 0 1 2 3 4 5 6 7 8 9 10 Decentralised

C12. What was the extent of your client and project evaluation prior to engagement?
Minimum evaluation (e.g. only financial consideration) 0 1 2 3 4 5 6 7 8 9 10 Thorough evaluation of all aspects

Please score the following attributes of the client on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Client Attributes	Negative Positive
C14.	Financial soundness (i.e. stability and status)	0 1 2 3 4 5 6 7 8 9 10
C15.	Experience in the type of case project	0 1 2 3 4 5 6 7 8 9 10
C16.	Experience in the size of case project	0 1 2 3 4 5 6 7 8 9 10
C18.	Past performance generally	0 1 2 3 4 5 6 7 8 9 10
C19.	Past performance in achieving project budget	0 1 2 3 4 5 6 7 8 9 10
C20.	Past performance in achieving project schedule	0 1 2 3 4 5 6 7 8 9 10
C21.	Past performance in good quality project	0 1 2 3 4 5 6 7 8 9 10
C22.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0 1 2 3 4 5 6 7 8 9 10
C23.	Project management experience, i.e.project team organisation	0 1 2 3 4 5 6 7 8 9 10
C24.	Project monitoring experience (e.g. monitoring progress)	0 1 2 3 4 5 6 7 8 9 10
C25.	Experience with quality assurance procedures	0 1 2 3 4 5 6 7 8 9 10
C26.	Qualification and experience of client representative	0 1 2 3 4 5 6 7 8 9 10
C27.	Previous working relationship between architect and client	0 1 2 3 4 5 6 7 8 9 10

In respect of achieving your project objectives for the 'case project' please indicate your levels of satisfaction acquired for each of the following client performance indicators.

Client Performance Criteria	Level of Satisfaction on case project low high
Understanding of Project Requirements	
• Quality of brief, in terms of clarity	0 1 2 3 4 5 6 7 8 9 10
• Quality of brief, in terms of adequacy and appropriateness	0 1 2 3 4 5 6 7 8 9 10
• Understanding of building process	0 1 2 3 4 5 6 7 8 9 10
• Knowing what they want early	0 1 2 3 4 5 6 7 8 9 10
• Clarity of thinking (not changing their mind)	0 1 2 3 4 5 6 7 8 9 10
• Ability to convey what they want	0 1 2 3 4 5 6 7 8 9 10
Finance	
• Adequacy of funding for the project	0 1 2 3 4 5 6 7 8 9 10
• Timeliness of payment	0 1 2 3 4 5 6 7 8 9 10
• Ease of financial approval due to variations	0 1 2 3 4 5 6 7 8 9 10
Decision Making	
• Ability to make rapid and decisive decisions	0 1 2 3 4 5 6 7 8 9 10
• Quality of the decisions	0 1 2 3 4 5 6 7 8 9 10
• Unity (i.e. clear and single voice)	0 1 2 3 4 5 6 7 8 9 10
Management skills	
• Delegation (give lead designer proper level of authority)	0 1 2 3 4 5 6 7 8 9 10
• Organisational skills	0 1 2 3 4 5 6 7 8 9 10
• Performance in pre-planning (early stages pf'mance)	0 1 2 3 4 5 6 7 8 9 10
• Administration	0 1 2 3 4 5 6 7 8 9 10
Support to Contractor / Architect	
• Information support (quality, timely, etc.)	0 1 2 3 4 5 6 7 8 9 10
• Adequacy of time (achievable and realistic timescale)	0 1 2 3 4 5 6 7 8 9 10
• Providing enough resources	0 1 2 3 4 5 6 7 8 9 10
• Monitoring progress / performance	0 1 2 3 4 5 6 7 8 9 10
• Adequate continuous involvement	0 1 2 3 4 5 6 7 8 9 10
• Ability to balance between involvement and interference	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Integrity and honesty	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Commitment to project	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to problems (queries) that arise	0 1 2 3 4 5 6 7 8 9 10
• Understanding architect difficulties	0 1 2 3 4 5 6 7 8 9 10
• Attitude to variations caused by client changes	0 1 2 3 4 5 6 7 8 9 10
• Allowing architect to enjoy projects	0 1 2 3 4 5 6 7 8 9 10
• Appreciation of architecture	0 1 2 3 4 5 6 7 8 9 10
• Ability to encourage attitude of pro-activeness of all	0 1 2 3 4 5 6 7 8 9 10
• Attitude towards advice (respect, open to solutions, flexible, receptiveness towards ideas)	0 1 2 3 4 5 6 7 8 9 10
• General feeling on how enjoyable/ pleasant client	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of client performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the client?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

This is the end of questionnaire. Thank you very much for your help.

Performance and Satisfaction Research
(Contractor Questionnaire)

This questionnaire represents part of a research programme aimed at developing a tool to predict levels of performance and satisfaction for the three main participants in the construction project coalition, i.e. clients, contractors and architects. This tool will enable members of the project coalition to foresee problems and forecast performance before project commencement. For example, contractors will be able to predict the performance of their clients and architects allowing appropriate corrective actions to be implemented, e.g. to mitigate under-performing clients and architects so that overall project performance can be improved.

We would like you to consider a recent (i.e. last 2 years) building project for which your company were the main contractor (referred to hereafter as the 'case project'). Preferably, but not exclusively, this 'case project' should be located in the UK and have been procured using the traditional route or a form of partnering. <u>You will need to relate all your responses to the questions in this questionnaire to this one case project</u>. Due to the nature of the information requested, we have deliberately designed the questionnaire to avoid identifying projects, naming other participants, etc. The first section of the questionnaire seeks information concerning you and your company. The second section seeks to categorise the characteristics of the case project. The final sections ask you to indicate the attributes and satisfaction levels derived from key participant performance criteria, again for the case project. Please note, if you have other attributes, characteristics or criteria, please feel free to comment and add. <u>All the information provided will be held in strict confidence and used for research purposes only</u>. A SAE is enclosed for your convenience.

Many of the questions presented require you to indicate your response on a scale. For example: How would you gauge the complexity of the case project:

Easy Highly complex

0 1 2 3 4 5 ⑥ 7 8 9 10

If you considered the case project to be, say somewhat complicated, you may rate the complexity a value of 6, and therefore circle this value to indicate your response as shown.

If you would like further information or have any queries, please do not hesitate to contact me. If you would like to receive a summary of the research findings, please tick here ☐.

Thank you for your kind attention and assistance.

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Section 1 - Your details

Respondent Details

Your name : .... Name of Employer : ....

Your position : .... Department : ....

Contact address : ....

Telephone : .... Fax : ....E-mail: ....

Respondent Attributes

R02. How long have you been involved in building construction projects? ....years

R04. How many similar projects (to the 'case project') have you been involved in the last five years? ....projects

How would you gauge your overall satisfaction of all projects you have undertaken in terms of the following:

	Satisfaction in terms of	Dissatisfied										Satisfied
R06.	Client performance	0	1	2	3	4	5	6	7	8	9	10
R07.	Architect performance	0	1	2	3	4	5	6	7	8	9	10

Please indicate your general perception on the following statements concerning clients in the UK construction industry

	Perception of clients	False										True
R09.	Do not know what they want	0	1	2	3	4	5	6	7	8	9	10
R10.	Always changing their mind	0	1	2	3	4	5	6	7	8	9	10
R14.	Always want to minimise cost without considering quality	0	1	2	3	4	5	6	7	8	9	10
R15.	Tend to be influenced by their initial advisors (e.g. QS, architect)	0	1	2	3	4	5	6	7	8	9	10

Please indicate your general perception on the following statements concerning architects in the UK construction industry

	Perception of architects	False										True
R16.	Do not listen to views other coalition members	0	1	2	3	4	5	6	7	8	9	10
R17.	More interested in design aesthetics than buildability	0	1	2	3	4	5	6	7	8	9	10
R18.	Unable to meet deadlines (late information delivery)	0	1	2	3	4	5	6	7	8	9	10
R19.	Poor management skills	0	1	2	3	4	5	6	7	8	9	10
R20.	Poor technical skills	0	1	2	3	4	5	6	7	8	9	10
R21.	Unreliable	0	1	2	3	4	5	6	7	8	9	10
R22.	Disorganised	0	1	2	3	4	5	6	7	8	9	10

Company Attributes

F03. How many people are employed by your company? ....employees

Section 2 - 'Case project' attributes

Please relate all following responses to just one recent 'case project' as described previously.

P01. Type of project:
☐ new building ☐ refurbishment ☐ extension to existing premises ☐ other, please specify ....

P02. Type of building:
☐ office ☐ retail ☐ residential ..... ☐ industrial ...... ☐ public ...... ☐ other, please specify ....

P06. What procurement route did you adopt on this project?
☐ traditional ☐ design and build ☐ partnering ☐ other, specify............

P09. What was the planned duration of the project? ....months

P10. Did the project overrun? Yes / No (choose)
P11. If so, by how much time? .... days/weeks/months (choose)

P12. What was the tender sum for the project? £ ....

P13. Did the project finish overbudget? Yes / No (choose)
P14. If so, by how much money? £ ....

P15. How would you gauge the severity (<u>in terms of value</u>) of variations on this case project?
Least severe 0 1 2 3 4 5 6 7 8 9 10 Most severe

With regard to the source or cause of these variations, how would you assess the contribution of the following parties?

	Cause of Variations	Never Always
P17.	Client	0 1 2 3 4 5 6 7 8 9 10
P18.	Architect	0 1 2 3 4 5 6 7 8 9 10
P19.	Contractor	0 1 2 3 4 5 6 7 8 9 10

P21. How would you gauge the level of design complexity on this project?
Easy /typical 0 1 2 3 4 5 6 7 8 9 10 Extremely complex

P23. In percentage terms, at the commencement of construction works on site, how much of the design had been completed? ....%

How would you gauge the impact of the following constraints on overall project performance?

	Constraints	No impact Very high impact
P26.	Weather conditions	0 1 2 3 4 5 6 7 8 9 10
P27.	Government regulations (e.g. planning permit)	0 1 2 3 4 5 6 7 8 9 10

With regard to the location of the project, please indicate the following:

	Remoteness from	Local (within 10 mile radius) — Distant (more than 300 miles radius)
P29.	client home office	0 1 2 3 4 5 6 7 8 9 10
P30.	architect home office	0 1 2 3 4 5 6 7 8 9 10

P32. How would you gauge the interaction between contractor and architect prior to on site work?

Low 0 1 2 3 4 5 6 7 8 9 10 High

Section 3 - Client attributes and performance criteria

In the following sections, you will be asked questions concerning the client of the 'case project'. Note: You will <u>not</u> be asked to reveal the identification of the company.

C01. What is the nature of client business?

☐ retail ☐ finance ☐ industrial ☐ other, please specify ....

C05. On how many projects has your company worked with this client before? ....projects

C06. How many similar types of project has your client undertaken within the last five years (approx.)? ....projects

C07. Did the client have a separate department or division which dealt with construction? Yes / No (choose)

C08. If so, how would you gauge the capability of that department in handling construction projects?

Low 0 1 2 3 4 5 6 7 8 9 10 High

C09. How would you gauge the client's construction work load when executing the case project?

No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

C10. How would you describe the client's organisational structure when executing the case project?

Simple 0 1 2 3 4 5 6 7 8 9 10 Complex

C11. How would you describe the client's communication channel when executing the case project?

Centralised 0 1 2 3 4 5 6 7 8 9 10 Decentralised

C12. What was the extent of your client and project evaluation prior to contract award?

Minimum evaluation (e.g. only financial consideration) 0 1 2 3 4 5 6 7 8 9 10 Thorough evaluation of all aspects

Please score the following attributes of the client on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Client Attributes	**Negative**										**Positive**
C14.	Financial soundness (i.e. stability and status)	0	1	2	3	4	5	6	7	8	9	10
C15.	Experience in the type of case project	0	1	2	3	4	5	6	7	8	9	10
C16.	Experience in the size of case project	0	1	2	3	4	5	6	7	8	9	10
C18.	Past performance generally	0	1	2	3	4	5	6	7	8	9	10
C19.	Past performance in achieving project budget	0	1	2	3	4	5	6	7	8	9	10
C20.	Past performance in achieving project schedule	0	1	2	3	4	5	6	7	8	9	10
C21.	Past performance in good quality project	0	1	2	3	4	5	6	7	8	9	10
C22.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0	1	2	3	4	5	6	7	8	9	10
C23.	Project management experience, i.e.project team organisation	0	1	2	3	4	5	6	7	8	9	10
C24.	Project monitoring experience (e.g. monitoring progress)	0	1	2	3	4	5	6	7	8	9	10
C25.	Experience with quality assurance procedures	0	1	2	3	4	5	6	7	8	9	10
C26.	Qualification and experience of client representative	0	1	2	3	4	5	6	7	8	9	10
C27.	Previous working relationship between contractor and client	0	1	2	3	4	5	6	7	8	9	10

In respect of achieving your project objectives for the 'case project' please indicate your levels of satisfaction acquired for each of the following client performance indicators.

Client Performance Criteria	**Level of Satisfaction on case project** low … high
Understanding of Project Requirements	
• Quality of brief, in terms of clarity	0 1 2 3 4 5 6 7 8 9 10
• Quality of brief, in terms of adequacy and appropriateness	0 1 2 3 4 5 6 7 8 9 10
• Understanding of building process	0 1 2 3 4 5 6 7 8 9 10
• Knowing what they want early	0 1 2 3 4 5 6 7 8 9 10
• Clarity of thinking (not changing their mind)	0 1 2 3 4 5 6 7 8 9 10
• Ability to convey what they want	0 1 2 3 4 5 6 7 8 9 10
Finance	
• Adequacy of funding for the project	0 1 2 3 4 5 6 7 8 9 10
• Timeliness of payment	0 1 2 3 4 5 6 7 8 9 10
• Ease of financial approval due to variations	0 1 2 3 4 5 6 7 8 9 10
Decision Making	
• Ability to make rapid and decisive decisions	0 1 2 3 4 5 6 7 8 9 10
• Quality of the decisions	0 1 2 3 4 5 6 7 8 9 10
• Unity (i.e. clear and single voice)	0 1 2 3 4 5 6 7 8 9 10
Management skills	
• Delegation (give lead designer proper level of authority)	0 1 2 3 4 5 6 7 8 9 10
• Organisational skills	0 1 2 3 4 5 6 7 8 9 10
• Performance in pre-planning (early stages performance)	0 1 2 3 4 5 6 7 8 9 10
• Administration	0 1 2 3 4 5 6 7 8 9 10

Client Performance Criteria	**Level of Satisfaction on case project** low … high
Support to Contractor / Architect	
• Information support (quality, timely, etc.)	0 1 2 3 4 5 6 7 8 9 10
• Adequacy of time (achievable and realistic timescale)	0 1 2 3 4 5 6 7 8 9 10
• Providing enough resources	0 1 2 3 4 5 6 7 8 9 10
• Monitoring progress / performance	0 1 2 3 4 5 6 7 8 9 10
• Adequate continuous involvement	0 1 2 3 4 5 6 7 8 9 10
• Ability to balance between involvement and interference	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Integrity and honesty	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Commitment to project	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to problems (queries) that arise	0 1 2 3 4 5 6 7 8 9 10
• Understanding contractor difficulties	0 1 2 3 4 5 6 7 8 9 10
• Attitude to variations caused by client changes	0 1 2 3 4 5 6 7 8 9 10
• Allowing architect to enjoy projects	0 1 2 3 4 5 6 7 8 9 10
• Appreciation of architecture	0 1 2 3 4 5 6 7 8 9 10
• Ability to encourage attitude of pro-activeness of all	0 1 2 3 4 5 6 7 8 9 10
• Attitude towards advice (respect, open to solutions, flexible, receptiveness towards ideas)	0 1 2 3 4 5 6 7 8 9 10
• General feeling on how enjoyable/ pleasant client	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of client performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the client?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

Section 4 - Architect attributes and performance criteria

In the following sections, you will be asked questions concerning the architect employed on the 'case project'. Note: You will <u>not</u> be asked to reveal the identification of the architect or architect company. If the 'case project' was not design and build, please do your best to answer these questions.

A03. How many employees did the architectural practice have?

☐ less than 10 ☐ 11 to 50 ☐ 51 to 200 ☐ above 200

A05. On how many projects has your company worked with this architect before? ....projects

A14. How would you gauge the architect's work load when executing this project?

No work 0 1 2 3 4 5 6 7 8 9 10 Extremely busy

A18. Have you previously worked with the project architects appointed to this project? Yes / No (choose)

Please score the following attributes of the architect on the case project:

Note: **Negative** indicates extremely poor, bad, low, small; whereas **Positive** indicates excellent, good, high, large.

	Architect Attributes	Negative										Positive
A19.	Financial soundness (i.e. stability and status)	0	1	2	3	4	5	6	7	8	9	10
A20.	Experience in the type of case project	0	1	2	3	4	5	6	7	8	9	10
A21.	Experience in the size of case project	0	1	2	3	4	5	6	7	8	9	10
A24.	Past performance in the last project (before case project)	0	1	2	3	4	5	6	7	8	9	10
A25.	Reputation in speed of information delivery	0	1	2	3	4	5	6	7	8	9	10
A26.	Reputation in adherence to budget	0	1	2	3	4	5	6	7	8	9	10
A27.	Reputation in quality of design	0	1	2	3	4	5	6	7	8	9	10
A28.	Reputation in litigation (*note:* **Positive** *means no litigation*)	0	1	2	3	4	5	6	7	8	9	10
A30.	Qualification and experience of director / principal	0	1	2	3	4	5	6	7	8	9	10
A31.	Qualification and experience of project architect	0	1	2	3	4	5	6	7	8	9	10
A32.	Quality assurance system	0	1	2	3	4	5	6	7	8	9	10
A33.	Previous working relationship between contractor and architect	0	1	2	3	4	5	6	7	8	9	10

In respect of achieving your project objectives for the 'case project', please indicate your levels of satisfaction acquired for each of the following architect performance indicators.

Architect Performance Criteria	Level of Satisfaction on case project low high
Pre-construction Stage	
• First interview and design presentation (visibility)	0 1 2 3 4 5 6 7 8 9 10
• Ability to develop brief and resolution of the brief	0 1 2 3 4 5 6 7 8 9 10
• Method statement (ability to explain how the project will be handled)	0 1 2 3 4 5 6 7 8 9 10
• Understanding of client culture (e.g. nature of client company) to assess the real need	0 1 2 3 4 5 6 7 8 9 10
Quality of Design	
• Design suitability to solution (relevancy, practicallity)	0 1 2 3 4 5 6 7 8 9 10
• Design buildability / constructability	0 1 2 3 4 5 6 7 8 9 10
• Design flair or aesthetic sense and innovation	0 1 2 3 4 5 6 7 8 9 10
• Design to provide value for money	0 1 2 3 4 5 6 7 8 9 10
• Design to incorporate health and safety issues	0 1 2 3 4 5 6 7 8 9 10
• Design concern for environmental issues	0 1 2 3 4 5 6 7 8 9 10
• Design simplicity for operations and maintenance	0 1 2 3 4 5 6 7 8 9 10
• Design adaptability or sustainability	0 1 2 3 4 5 6 7 8 9 10
• Quality of detail drawing and specifications (e.g. accuracy, completeness)	0 1 2 3 4 5 6 7 8 9 10
Management Skill	
• Design management and supervision	0 1 2 3 4 5 6 7 8 9 10
• Ability to manage the construction process (as contract administrator)	0 1 2 3 4 5 6 7 8 9 10
• Coordination between team members or consultants	0 1 2 3 4 5 6 7 8 9 10
• Company organisational skills & organisational structure	0 1 2 3 4 5 6 7 8 9 10
• Management of resources (commitment of resources)	0 1 2 3 4 5 6 7 8 9 10

Architect Performance Criteria	Level of Satisfaction on case project low high
Technical Skill	
• Practical construction knowledge	0 1 2 3 4 5 6 7 8 9 10
• Suitability and quality of major building components or products selected	0 1 2 3 4 5 6 7 8 9 10
• Incorporation of mechanical and electrical services into the structure	0 1 2 3 4 5 6 7 8 9 10
• Understanding and compliance with legislation and statutory requirements (CDM, fire regl., etc.)	0 1 2 3 4 5 6 7 8 9 10
Quality of Services	
• Effective handling of complaints	0 1 2 3 4 5 6 7 8 9 10
• Telephone inquiries and correspondence handled courteously and adequately	0 1 2 3 4 5 6 7 8 9 10
• Speed and reliability of service (e.g. redrawing)	0 1 2 3 4 5 6 7 8 9 10
• Responsiveness to client /contractor queries (flexibility)	0 1 2 3 4 5 6 7 8 9 10
• Ability to make rapid and decisive decisions	0 1 2 3 4 5 6 7 8 9 10
• Commitment of key persons (active & continuous)	0 1 2 3 4 5 6 7 8 9 10
• Willingness to draft the documents / drawings, not only do conceptual work	0 1 2 3 4 5 6 7 8 9 10
• Follow up (e.g. defects) or services offered after project completion	0 1 2 3 4 5 6 7 8 9 10
• Corporate hospitality	0 1 2 3 4 5 6 7 8 9 10
Attitude	
• Integrity	0 1 2 3 4 5 6 7 8 9 10
• Collaborative / spirit of cooperation / team work	0 1 2 3 4 5 6 7 8 9 10
• Keep the client informed (willingness to involve cl.)	0 1 2 3 4 5 6 7 8 9 10
• Communication with other coalition members	0 1 2 3 4 5 6 7 8 9 10
• Commercial attitude (e.g. additional fees)	0 1 2 3 4 5 6 7 8 9 10
• Pro-active to know site problems (e.g. by regular site visit)	0 1 2 3 4 5 6 7 8 9 10
• Attitude in dealing with client and contractor	0 1 2 3 4 5 6 7 8 9 10
• Avoidance of design changes	0 1 2 3 4 5 6 7 8 9 10
• Listen to what client wants (customer focus)	0 1 2 3 4 5 6 7 8 9 10
• Responsibility for their decision (understand the cost of their recommendations)	0 1 2 3 4 5 6 7 8 9 10
Main Criteria	
• General quality of building (both functionality and aesthetics)	0 1 2 3 4 5 6 7 8 9 10
• Compliance with information required schedule	0 1 2 3 4 5 6 7 8 9 10
• Compliance with requirements	0 1 2 3 4 5 6 7 8 9 10
• Compliance to budget	0 1 2 3 4 5 6 7 8 9 10

How would you gauge your overall satisfaction in respect of architect performance on the case project?

Low 0 1 2 3 4 5 6 7 8 9 10 High

How would you gauge the potential for repeat work with the architect?

Low potential 0 1 2 3 4 5 6 7 8 9 10 High potential

This is the end of questionnaire. Thank you very much for your help.

Appendix D:

Identification of potentially significant independent variables

Table D1 Identification of potentially significant independent variables of architects' and contractors' assessment based on client performance using correlation analysis

Identified Variables	ARCHITECT							CONTRACTOR						
	SAT1	SAT2	SAT3	SAT4	SAT5	AVES	TOTS	SAT1	SAT2	SAT3	SAT4	SAT5	AVES	TOTS
SATISFACTION ATTRIBUTES														
ASSESSOR														
RSEDU (1,2,3)														
RSPRO														
RSCOM														
RS5YR									✓					
RSSATPR														
RSSATCL	✓	✓	✓	✓	✓	✓	✓							✓
RSCLI1					✓					✓				
RSCLI2	✓				✓	✓				✓				
RSCLI3														
RSCLI4														
RSCLI5														
RSCLI6										✓				
RSCLI7												✓		
COMPANY ASSESSOR														
AR/COEST														
AR/COEMP											✓			
PERFORMANCE ATTRIBUTES														
PROJECT														
PRTPR (1,2)	✓		✓	✓		✓								
PRTBD (1,2,3,4)								✓	✓	✓		✓	✓	✓
PRSTO														
PR5YR														
PRROU (1,2,3)		✓			✓									
PRCTR (1,2,3)#														
PRCLA#														
PRDURPL											✓			
PRDUROV											✓			
PRDURTI											✓			
PRBUDTE		✓					✓	✓						
PRBUDOV		✓					✓	✓		✓				
PRBUDMO		✓					✓	✓			✓	✓	✓	✓
PRVARSE									✓	✓				✓
PRVARFR														
PRVARCL														
PRVARAR														
PRVARCO														
PRVAROT														
PRCOMDE		✓												
PRCOMCS														
PRDESCO											✓			
PRDURDE^														
PRCONGR														
PRCONWE														
PRCONGO					✓									
PRLOCAC														
PRLOCCL	✓				✓									
CLIENT														
CLNAT (1,2,3,4)										✓	✓	✓	✓	
CLATO (1,2,3,4)														
CLEMP (1,2,3,4)														
CLWKDBF		✓												
CLSIM5YR		✓												
CLORGST				✓	✓									
CLCOMCH				✓								✓	✓	
CLDEP														
CLDEPCA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CLDEPWL									✓	✓				
CLEVAAR/CO	✓	✓	✓		✓	✓								
CLPERCL														
CLATTFI	✓			✓	✓	✓					✓	✓		
CLATTTY										✓				
CLATTSI										✓		✓	✓	

Table D1 Identification of potentially significant independent variables of architects' and contractors' assessment based on client performance using correlation analysis (cont.)

Identified Variables	ARCHITECT							CONTRACTOR						
	SAT1	SAT2	SAT3	SAT4	SAT5	AVES	TOTS	SAT1	SAT2	SAT3	SAT4	SAT5	AVES	TOTS
CLATTGE														
CLATTPP	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
CLATTSC				✓				✓	✓	✓	✓	✓	✓	✓
CLATTBU	✓			✓				✓	✓	✓	✓	✓	✓	✓
CLATTQU								✓	✓	✓		✓	✓	
CLATTLI									✓	✓	✓	✓	✓	✓
CLATTPM	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CLATTAU	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
CLATTQA	✓		✓	✓	✓	✓		✓	✓	✓		✓	✓	✓
CLATTQE	✓			✓	✓	✓		✓	✓	✓		✓	✓	✓
CLATTWR	✓			✓		✓		✓		✓	✓	✓	✓	

Note: marked variables significantly correlated with satisfaction measures at 5% or less
only in contractors' assessment
^only in architects' assessment

Table D2 Identification of potentially significant independent variables of clients' and contractors' assessment based on architect performance using correlation analysis

Identified Variables	CLIENT							CONTRACTOR						
	SAT1	SAT2	SAT3	SAT4	SAT5	AVES	TOTS	SAT1	SAT2	SAT3	SAT4	SAT5	AVES	TOTS
SATISFACTION ATTRIBUTES														
ASSESSOR														
RSEDU (1,2,3)														
RSPRO												✓		
RSCOM														
RS5YR			✓						✓					
RSSATPR														
RSSATAR							✓			✓				
RSARC1	✓	✓		✓		✓	✓							
RSARC2	✓	✓		✓		✓	✓							
RSARC3	✓			✓			✓			✓				
RSARC4	✓													
RSARC5	✓						✓							✓
RSARC6	✓	✓		✓		✓	✓							
RSARC7	✓	✓					✓							✓
COMPANY ASSESSOR														
CLNAT*														
CL/COEST														
CL/COEMP														
CL/COABWVA														
PERFORMANCE ATTRIBUTES														
PROJECT														
PRTPR (1,2)			✓			✓								
PRTBD (1,2,3,4)														
PRSTO														
PRGFA														
PR5YR														
PRROU (1,2,3)	✓	✓		✓		✓			✓					
PRDURPL							✓						✓	
PRDUROV	✓	✓	✓	✓	✓	✓	✓						✓	
PRDURTI	✓	✓		✓		✓	✓						✓	
PRBUDTE							✓	✓						
PRBUDOV	✓	✓	✓		✓	✓	✓	✓	✓		✓		✓	✓
PRBUDMO	✓			✓	✓	✓	✓	✓						
PRVARSE	✓	✓		✓		✓	✓							
PRVARFR														
PRVARCL														
PRVARAR	✓	✓		✓		✓	✓	✓	✓			✓	✓	✓
PRVARCO														
PRVAROT														
PRCOMDE	✓			✓										
PRCOMCS														
PRDESCO	✓							✓						
PRCONGR														
PRCONWE			✓											
PRCONGO														
PRLOCAC														
PRLOCAR	✓										✓			
PRINT	✓	✓		✓		✓	✓	✓	✓		✓		✓	✓
ARCHITECT														
ARSI (1,2,3,4)														
ARATO (1,2,3,4)														
AREMP (1,2,3,4)														✓
ARWKDBF		✓			✓					✓				
ARWL			✓						✓					
ARINFAP														
ARPERAR								✓						
ARATTFI				✓										
ARATTTY			✓	✓				✓		✓	✓		✓	✓
ARATTSI			✓	✓	✓	✓								
ARATTGE														
ARATTPP	✓	✓			✓	✓		✓	✓	✓	✓	✓	✓	✓
ARATTSC	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
ARATTBU	✓	✓			✓	✓	✓	✓		✓	✓		✓	✓

Table D2 Identification of potentially significant independent variables of clients' and contractors' assessment based on architect performance using corr. analysis (cont.)

Identified	CLIENT							CONTRACTOR						
Variables	SAT1	SAT2	SAT3	SAT4	SAT5	AVES	TOTS	SAT1	SAT2	SAT3	SAT4	SAT5	AVES	TOTS
ARATTQU								✓	✓	✓	✓		✓	✓
ARATTLI								✓	✓					✓
ARATTIM														
ARATTDI								✓		✓				✓
ARATTSP	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
ARATTQC	✓			✓		✓		✓		✓	✓		✓	✓
ARATTWR	✓	✓		✓		✓	✓	✓			✓		✓	✓

Note: marked variables significantly correlated with satisfaction measures at 5% or less

* only in clients' assessment

Table D3 Identification of potentially significant independent variables of clients' and architects' assessment based on contractor performance using correlation analysis

Identified Variables	CLIENT						ARCHITECT					
	SAT1	SAT2	SAT3	SAT4	AVES	TOTS	SAT1	SAT2	SAT3	SAT4	AVES	TOTS
SATISFACTION ATTRIBUTES												
ASSESSOR												
RSEDU (1,2,3)												
RSPRO												
RSCOM												
RS5YR												
RSSATPR												
RSSATCO	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
RSCON1												
RSCON2		✓				✓		✓	✓			
RSCON3	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
RSCON4							✓	✓	✓		✓	
RSCON5	✓	✓	✓		✓		✓	✓	✓		✓	
RSCON6	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
RSCON7	✓	✓	✓		✓	✓	✓	✓	✓		✓	
COMPANY ASSESSOR												
CLNAT*												
CL/AREST												
CL/AREMP												
PERFORMANCE ATTRIBUTES												
PROJECT												
PRTPR (1,2)									✓		✓	✓
PRTBD (1,2,3,4)							✓	✓				
PRSTO							✓	✓	✓	✓	✓	
PR5YR												
PRROU (1,2,3)		✓		✓								
PRCTR (1, 2, 3)												
PRCLA												
PRDURPL				✓				✓				
PRDUROV	✓	✓	✓	✓	✓	✓		✓				
PRDURTI	✓		✓		✓	✓	✓	✓	✓	✓	✓	
PRBUDTE		✓										
PRBUDOV		✓		✓	✓	✓						
PRBUDMO	✓					✓						
PRVARSE	✓	✓		✓	✓	✓						✓
PRVARFR												
PRVARCL												
PRVARAR												
PRVARCO	✓	✓	✓		✓	✓				✓	✓	
PRVAROT												
PRCOMDE												✓
PRCOMCS												
PRDESCO												
PRCONGR												✓
PRCONWE	✓	✓	✓	✓	✓	✓						
PRCONGO												
PRLOCAC								✓				
PRLOCCO												
PRINT		✓	✓		✓		✓			✓	✓	✓
CONTRACTOR												
COSI (1,2,3,4)												
COATO (1,2,3,4)												
COEMP (1,2,3,4)												
COWKDBF												
COWL	✓		✓		✓	✓						
COSELCO (1, 2)	✓	✓			✓							
COEVACL/AR	✓	✓	✓	✓	✓							
COPAYCO (1, 2)		✓										
COINFAP												
COPERCO	✓	✓			✓	✓						
COATTFI	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓
COATTTY	✓	✓	✓	✓	✓	✓			✓			✓
COATTSI	✓	✓	✓	✓	✓	✓				✓		✓

Table D3 Identification of potentially significant independent variables of clients' and architects' assessment based on contractor performance using corr. analysis (cont.)

Identified Variables	CLIENT						ARCHITECT					
	SAT1	SAT2	SAT3	SAT4	AVES	TOTS	SAT1	SAT2	SAT3	SAT4	AVES	TOTS
COATTGE												
COATTRE							✓	✓	✓	✓	✓	✓
COATTPP	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	
COATTSC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
COATTBU	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
COATTQU	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
COATTLI							✓	✓	✓	✓	✓	✓
COATTIM						✓	✓	✓	✓	✓	✓	✓
COATTDI	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
COATTSP	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
COATTHS	✓	✓	✓	✓	✓	✓						
COATTTR	✓	✓	✓		✓	✓		✓		✓	✓	
COATTQC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
COATTSU										✓		
COATTLA										✓		
COATTPL												
COATTWR	✓					✓	✓	✓		✓	✓	

Note: marked variables significantly correlated with satisfaction measures at 5% or less
* only in clients' assessment

Appendix E:

Lists of (Original, Deleted and Potentially Significant) Independent Variables

Table E.1 List of (original, deleted and potentially significant) independent variables of architects' and contractors' assessment of client performance

Variable Name	Code	Questionnaire Items	Measure	Deleted Due to 20% Missing		Potentially Significant Variables at 5%		
				Ar. Ass.	Co. Ass.	Ar. Ass.	Co. Ass.	Overall
SATISFACTION ATTRIBUTES								
ASSESSOR								
respondent education	RSEDU (1,2,3)	R01	nominal					
involved in project	RSPRO	R02	years					
working for company	RSCOM	R03	years					
involved in similar projects within 5 years	RS5YR	R04	No.				✓	✓
satisfaction on project performance	RSSATPR	R05	likert 0-10					
satisfaction on client performance	RSSATCL	R06	likert 0-10			✓	✓	✓
perception on client: client's wants	RSCLI1	R09	likert 0-10			✓	✓	✓
perception on client: changing mind	RSCLI2	R10	likert 0-10			✓	✓	✓
perception on client: hidden	RSCLI3	R11	likert 0-10					
perception on client: pay late	RSCLI4	R12	likert 0-10					
perception on client: accept ideas	RSCLI5	R13	likert 0-10					
perception on client: minimise cost	RSCLI6	R14	likert 0-10				✓	✓
perception on client: advisors' influence	RSCLI7	R15	likert 0-10				✓	✓
COMPANY ASSESSOR								
company establishment	AR/COEST	F02	years					
number of employees	AR/COEMP	F03	No.				✓	✓
company annual turn over	AR/COATO	F04	Sterling (M)	×				
no. annual building works	AR/COABWNO	F05	No.	×				
total value of annual building works	AR/COABWVA	F06	Sterling (M)	×				
PERFORMANCE ATTRIBUTES								
PROJECT								
type of project	PRTPR (1,2)	P01	nominal			✓		✓
type of building	PRTBD (1,2,3,4)	P02	nominal				✓	✓
number of storeys	PRSTO	P03	No.					
gross floor area	PRGFA	P04	area (m^2)		×			
procured similar projects within 5 years	PR5YR	P05	No.					
procurement route	PRROU (1,2,3)	P06	nominal			✓		✓
type of contract #	PRCTR (1,2,3)	P07	nominal					
clarity and understanable of contract #	PRCLA	P08	likert 0-10					
planned duration	PRDURPL	P09	time (months)				✓	✓
overrun	PRDUROV	P10	Yes/No				✓	✓
overrun duration	PRDURTI	P11	time (months)				✓	✓
tender sum	PRBUDTE	P12	Sterling (M)			✓	✓	✓
overbudget	PRBUDOV	P13	Yes/No			✓	✓	✓
overbudget cost	PRBUDMO	P14	Sterling (M)			✓	✓	✓
severity of variations	PRVARSE	P15	likert 0-10				✓	✓
frequency of variations	PRVARFR	P16	likert 0-10					
cause of variations by client	PRVARCL	P17	likert 0-10					
cause of variations by architect	PRVARAR	P18	likert 0-10					
cause of variations by contractor	PRVARCO	P19	likert 0-10					
cause of variations by others	PRVAROT	P20	likert 0-10					
design complexity	PRCOMDE	P21	likert 0-10			✓		✓
construction complexity	PRCOMCS	P22	likert 0-10					
design completed before work on site	PRDESCO	P23	percentage				✓	✓
design duration ^	PRDURDE	P24	time (months)					
constraint by ground conditions	PRCONGR	P25	likert 0-10					
constraint by weather conditions	PRCONWE	P26	likert 0-10					
constraint by government regulations	PRCONGO	P27	likert 0-10			✓		✓
ease of access to project location	PRLOCAC	P28	likert 0-10					
remoteness from client office	PRLOCCL	P29	likert 0-10			✓		✓
CLIENT								
nature of client business	CLNAT (1,2,3,4)	C01	nominal				✓	✓
company annual turn over	CLATO (1,2,3,4)	C02	ordinal					
number of employees	CLEMP (1,2,3,4)	C03	ordinal					
company establishment	CLEST	C04	years		×			
no. previous project worked with client	CLWKDBF	C05	No.			✓		✓
no. similar project by client within 5 years	CLSIM5YR	C06	No.			✓		✓
client separate department	CLDEP	C07	Yes/No					
department capacity	CLDEPCA	C08	likert 0-10			✓	✓	✓
department work load	CLDEPWL	C09	likert 0-10				✓	✓
client's organisation structure	CLORGST	C10	likert 0-10			✓		✓
client's communication channel	CLCOMCH	C11	likert 0-10			✓	✓	✓
contractor evaluation prior contract award	CLEVAAR/CO	C12	likert 0-10			✓		✓
previous relationship with site personnel	CLPERCL	C13	Yes/No					
client attributes: financial	CLATTFI	C14	likert 0-10			✓	✓	✓
client attributes: type	CLATTTY	C15	likert 0-10				✓	✓
client attributes: size	CLATTSI	C16	likert 0-10				✓	✓
client attributes: geographical condition	CLATTGE	C17	likert 0-10					
client attributes: past performance	CLATTPP	C18	likert 0-10			✓	✓	✓

Table E.1 List of (original, deleted and potentially significant) independent variables of architects' and contractors' assessment of client performance (cont.)

Variable Name	Code	Questionnaire Items	Measure	Deleted Due to 20% Missing		Potentially Significant Variables at 5%		
				Ar. Ass.	Co. Ass.	Ar. Ass.	Co. Ass.	Overall
client attributes: time reputation	CLATTSC	C19	likert 0-10			✓	✓	✓
client attributes: cost reputation	CLATTBU	C20	likert 0-10			✓	✓	✓
client attributes: quality reputation	CLATTQU	C21	likert 0-10				✓	✓
client attributes: litigation	CLATTLI	C22	likert 0-10				✓	✓
client attributes: project management	CLATTPM	C23	likert 0-10			✓	✓	✓
client attributes: project monitoring	CLATTAU	C24	likert 0-10			✓	✓	✓
client attributes: quality assurance	CLATTQA	C25	likert 0-10			✓	✓	✓
client attributes: representative	CLATTQE	C26	likert 0-10			✓	✓	✓
contractor attributes: working relationship	CLATTWR	C27	likert 0-10			✓	✓	✓

Note: # only in contractors' assessment
^only in architects' assessment

Table E.2 List of (original, deleted and potentially significant) independent variables of clients' and contractors' assessment of architect performance

Variable Name	Code	Questionnaire Item	Measure	Deleted Due to 20% Missing		Potentially Significant Variables at 5%		
				Cl. Ass.	Co. Ass.	Cl. Ass.	Co. Ass.	Overall
SATISFACTION ATTRIBUTES								
ASSESSOR								
respondent education	RSEDU (1,2,3)	R01	nominal					
involved in project	RSPRO	R02	years				✓	✓
working for company	RSCOM	R03	years					
involved in similar projects within 5 years	RS5YR	R04	No.			✓	✓	✓
satisfaction on project performance	RSSATPR	R05	likert 0-10					
satisfaction on architect performance	RSSATAR	R07	likert 0-10			✓	✓	✓
perception on architect: arrogant	RSARC1	R16	likert 0-10			✓		✓
perception on architect: buildability	RSARC2	R17	likert 0-10			✓		✓
perception on architect: delivery	RSARC3	R18	likert 0-10			✓	✓	✓
perception on architect: management	RSARC4	R19	likert 0-10			✓		✓
perception on architect: technical	RSARC5	R20	likert 0-10			✓	✓	✓
perception on architect: unreliable	RSARC6	R21	likert 0-10			✓		✓
perception on architect: disorganised	RSARC7	R22	likert 0-10			✓	✓	✓
COMPANY ASSESSOR								
nature of client business *	CLNAT	F01						
company establishment	CL/COEST	F02	years					
number of employees	CL/COEMP	F03	No.					
company annual turn over	CL/COATO	F04	Sterling (M)	×				
no. annual building works	CL/COABWNO	F05	No.		×			
total value of annual building works	CL/COABWVA	F06	Sterling (M)					
PERFORMANCE ATTRIBUTES								
PROJECT								
type of project	PRTPR (1,2)	P01	nominal			✓		✓
type of building	PRTBD (1,2,3,4)	P02	nominal					
number of storeys	PRSTO	P03	No.					
gross floor area	PRGFA	P04	area (m^2)					
procured similar projects within 5 years	PR5YR	P05	No.					
procurement route	PRROU (1,2,3)	P06	nominal			✓	✓	✓
planned duration	PRDURPL	P09	time (months)			✓	✓	✓
overrun	PRDUROV	P10	Yes/No			✓	✓	✓
overrun duration	PRDURTI	P11	time (months)			✓	✓	✓
tender sum	PRBUDTE	P12	Sterling (M)			✓	✓	✓
overbudget	PRBUDOV	P13	Yes/No			✓	✓	✓
overbudget cost	PRBUDMO	P14	Sterling (M)			✓	✓	✓
severity of variations	PRVARSE	P15	likert 0-10			✓		✓
frequency of variations	PRVARFR	P16	likert 0-10					
cause of variations by client	PRVARCL	P17	likert 0-10					
cause of variations by architect	PRVARAR	P18	likert 0-10			✓	✓	✓
cause of variations by contractor	PRVARCO	P19	likert 0-10					
cause of variations by others	PRVAROT	P20	likert 0-10					
design complexity	PRCOMDE	P21	likert 0-10			✓		✓
construction complexity	PRCOMCS	P22	likert 0-10					
design completed before work on site	PRDESCO	P23	percentage			✓	✓	✓
design duration	PRDURDE	P24	time (months)		×			
constraint by ground conditions	PRCONGR	P25	likert 0-10					
constraint by weather conditions	PRCONWE	P26	likert 0-10			✓		✓
constraint by government regulations	PRCONGO	P27	likert 0-10					
ease of access to project location	PRLOCAC	P28	likert 0-10					
remoteness from architect office	PRLOCAR	P30	likert 0-10			✓	✓	✓
interaction between contractor and architect	PRINT	P32	likert 0-10			✓	✓	✓
ARCHITECT								
architect size (catchment)	ARSI (1,2,3,4)	A1	ordinal					
company annual turn over	ARATO (1,2,3,4)	A2	ordinal					
number of employees	AREMP (1,2,3,4)	A3	ordinal				✓	✓
company establishment	AREST	A4	years		×			
no. previous project undertaken by architect	ARWKDBF	A5	No.			✓	✓	✓
method of architect selection	ARSELAR (1, 2)	A6	nominal		×			
architect selection criteria: technical *	ARSCRTA	A7	likert 0-10	×				
architect selection criteria: past experience *	ARSCRPE	A8	likert 0-10	×				
architect selection criteria: quality *	ARSCRQD	A9	likert 0-10	×				
architect selection criteria: reference *	ARSCRRE	A10	likert 0-10	×				
architect selection criteria: fee *	ARSCRTE	A11	likert 0-10	×				
architect selection criteria: reputation *	ARSCRPU	A12	likert 0-10	×				
architect evaluation prior contract award	AREVACL/CO	A13	likert 0-10		×			
architect work load	ARWL	A14	likert 0-10			✓	✓	✓
method of architect payment	ARPAYAR (1, 2)	A15	nominal		×			

Table E.2 List of (original, deleted and potentially significant) independent variables of clients' and contractors' assessment of architect performance (cont.)

Variable Name	Code	Questionnaire Item	Measure	Deleted Due to 20% Missing		Potentially Significant Variables at 5%		
				Cl. Ass.	Co. Ass.	Cl. Ass.	Co. Ass.	Overall
architect design fee (from total project cost)	ARFEE	A16	percentage	×	×			
influence on appointment of arch. personnel	ARINFAP	A17	likert 0-10					
previous relationship with architect personnel	ARPERAR	A18	Yes/No				✓	✓
architect attributes: financial	ARATTFI	A19	likert 0-10			✓		✓
architect attributes: type	ARATTTY	A20	likert 0-10			✓	✓	✓
architect attributes: size	ARATTSI	A21	likert 0-10			✓		✓
architect attributes: geographical	ARATTGE	A22	likert 0-10					
architect attributes: references	ARATTRE	A23	likert 0-10		×			
architect attributes: past performance	ARATTPP	A24	likert 0-10			✓	✓	✓
architect attributes: time reputation	ARATTSC	A25	likert 0-10			✓	✓	✓
architect attributes: cost reputation	ARATTBU	A26	likert 0-10			✓	✓	✓
architect attributes: quality reputation	ARATTQU	A27	likert 0-10				✓	✓
architect attributes: litigation	ARATTLI	A28	likert 0-10				✓	✓
architect attributes: claims	ARATTIM	A29	likert 0-10					
architect attributes: director / principal	ARATTDI	A30	likert 0-10				✓	✓
architect attributes: project architect	ARATTSP	A31	likert 0-10			✓	✓	✓
architect attributes: quality assurance	ARATTQC	A32	likert 0-10			✓	✓	✓
architect attributes: working relationship	ARATTWR	A33	likert 0-10			✓	✓	✓

Note: * only in clients' assessment

Table E.3 List of (original, deleted and potentially significant) independent variables of clients' and architects' assessment of contractor performance

Variable Name	Code	Questionnaire Item	Measure	Deleted Due to 20% Missing		Potentially Significant Variables at 5%		
				Cl. Ass.	Ar. Ass.	Cl. Ass.	Ar. Ass.	Overall
SATISFACTION ATTRIBUTES								
ASSESSOR								
respondent education	RSEDU (1,2,3)	R01	nominal					
involved in project	RSPRO	R02	years					
working for company	RSCOM	R03	years					
involved in similar projects within 5 years	RS5YR	R04	No.					
satisfaction on project performance	RSSATPR	R05	likert 0-10					
satisfaction on contractor performance	RSSATCO	R08	likert 0-10			✓	✓	✓
perception on contractor image	RSCON1	R23	likert 0-10					
perception on contractor claims	RSCON2	R24	likert 0-10			✓	✓	✓
perception on contractor on time	RSCON3	R25	likert 0-10			✓	✓	✓
perception on contractor contractual	RSCON4	R26	likert 0-10				✓	✓
perception on contractor untidy	RSCON5	R27	likert 0-10			✓	✓	✓
perception on contractor inefficient	RSCON6	R28	likert 0-10			✓	✓	✓
perception on contractor technology	RSCON7	R29	likert 0-10			✓	✓	✓
COMPANY ASSESSOR								
nature of client business *	CLNAT	F01	nominal					
company establishment	CL/AREST	F02	years					
number of employees	CL/AREMP	F03	No.					
company annual turn over	CL/ARATO	F04	Sterling (M)	×	×			
no. annual building works	CL/ARABWNO	F05	No.	×	×			
total value of annual building works	CL/ARABWVA	F06	Sterling (M)		×			
PERFORMANCE ATTRIBUTES								
PROJECT								
type of project	PRTPR (1,2)	P01	nominal				✓	✓
type of building	PRTBD (1,2,3,4)	P02	nominal				✓	✓
number of storeys	PRSTO	P03	No.				✓	✓
gross floor area	PRGFA	P04	area (m^2)		×			
procured similar projects within 5 years	PR5YR	P05	No.					
procurement route	PRROU (1,2,3)	P06	nominal			✓		✓
form of contract	PRCTR (1, 2, 3)	P07	nominal					
clarity and understanding of contract	PRCLA	P08	likert 0-10					
planned duration	PRDURPL	P09	time (months)			✓	✓	✓
overrun	PRDUROV	P10	Yes/No			✓	✓	✓
overrun duration	PRDURTI	P11	time (months)			✓	✓	✓
tender sum	PRBUDTE	P12	Sterling (M)			✓		✓
overbudget	PRBUDOV	P13	Yes/No			✓		✓
overbudget cost	PRBUDMO	P14	Sterling (M)			✓		✓
severity of variations	PRVARSE	P15	likert 0-10			✓	✓	✓
frequency of variations	PRVARFR	P16	likert 0-10					
cause of variations by client	PRVARCL	P17	likert 0-10					
cause of variations by architect	PRVARAR	P18	likert 0-10					
cause of variations by contractor	PRVARCO	P19	likert 0-10			✓	✓	✓
cause of variations by others	PRVAROT	P20	likert 0-10					
design complexity	PRCOMDE	P21	likert 0-10				✓	✓
construction complexity	PRCOMCS	P22	likert 0-10					
design completed before work on site	PRDESCO	P23	percentage					
constraint by ground conditions	PRCONGR	P25	likert 0-10				✓	✓
constraint by weather conditions	PRCONWE	P26	likert 0-10			✓		✓
constraint by government regulations	PRCONGO	P27	likert 0-10					
ease of access to project location	PRLOCAC	P28	likert 0-10				✓	✓
remoteness from contractor office	PRLOCCO	P31	likert 0-10					
interaction between contractor and architect	PRINT	P32	likert 0-10			✓	✓	✓
CONTRACTOR								
contractor size (catchment)	COSI (1,2,3,4)	O01	ordinal					
company annual turn over	COATO (1,2,3,4)	O02	ordinal					
number of employees	COEMP (1,2,3,4)	O03	ordinal					
company establishment	COEST	O04	years		×			
no. previous project undertaken by contractor	COWKDBF	O05	No.					
method of contractor selection	COSELCO (1, 2)	O06	nominal			✓		✓
contractor selection criteria: technical *	COSCRTA	O07	likert 0-10	×				
contractor selection criteria: past experience *	COSCRPE	O08	likert 0-10	×				
contractor selection criteria: quality & programme *	COSCRQP	O09	likert 0-10	×				
contractor selection criteria: reference *	COSCRRE	O10	likert 0-10	×				
contractor selection criteria: tender sum *	COSCRTE	O11	likert 0-10	×				
contractor selection criteria: reputation *	COSCRPU	O12	likert 0-10	×				
contractor evaluation prior contract award	COEVACL/AR	O13	likert 0-10			✓		✓
architect work load	COWL	O14	likert 0-10			✓		✓
method of contractor payment	COPAYCO (1, 2)	O15	nominal			✓		✓
difference between estimate and contractor bid	CODIFEST	O16	percentage	×				
difference between contractor bid and second	CODIFSEC	O17	percentage	×	×			

Table E.3 List of (original, deleted and potentially significant) independent variables of clients' and architects' assessment of contractor performance (cont.)

Variable Name	Code	Questionnaire Item	Measure	Deleted Due to 20% Missing		Potentially Significant Variables at 5%		
				Cl. Ass.	Ar. Ass.	Cl. Ass.	Ar. Ass.	Overall
influence on appointment of site personnel	COINFAP	O18	likert 0-10					
previous relationship with site personnel	COPERCO	O19	Yes/No			✓		✓
contractor attributes: financial soundness	COATTFI	O20	likert 0-10			✓	✓	✓
contractor attributes: experience in type of proj.	COATTTY	O21	likert 0-10			✓	✓	✓
contractor attributes: experience in size of proj.	COATTSI	O22	likert 0-10			✓	✓	✓
contractor attributes: exp. in geographical area	COATTGE	O23	likert 0-10					
contractor attributes: references	COATTRE	O24	likert 0-10				✓	✓
contractor attributes: past performance	COATTPP	O25	likert 0-10			✓	✓	✓
contractor attributes: time reputation	COATTSC	O26	likert 0-10			✓	✓	✓
contractor attributes: cost reputation	COATTBU	O27	likert 0-10			✓	✓	✓
contractor attributes: quality reputation	COATTQU	O28	likert 0-10			✓	✓	✓
contractor attributes: litigation reputation	COATTLI	O29	likert 0-10				✓	✓
contractor attributes: claim reputation	COATTIM	O30	likert 0-10			✓	✓	✓
contractor attributes: director	COATTDI	O31	likert 0-10			✓	✓	✓
contractor attributes: site personnel	COATTSP	O32	likert 0-10			✓	✓	✓
contractor attributes: health and safety	COATTHS	O33	likert 0-10			✓		✓
contractor attributes: training regime	COATTTR	O34	likert 0-10			✓	✓	✓
contractor attributes: quality control	COATTQC	O35	likert 0-10			✓	✓	✓
contractor attributes: subs and suppliers	COATTSU	O36	likert 0-10				✓	✓
contractor attributes: labour	COATTLA	O37	likert 0-10				✓	✓
contractor attributes: plant	COATTPL	O38	likert 0-10					
contractor attributes: working relationship	COATTWR	O39	likert 0-10			✓	✓	✓

Note: * only in clients' assessment

Appendix F:

Analysis of Project Attributes Representing the Characteristics of the Case Projects (Insignificant Results)

Appendix F1: The relationships between type of client and the other variables

Appendix F2: The relationships between procurement route and the other variables

Appendix F3: The relationships between method of contractor selection and the other variables

Appendix F4: The relationships between method of contractor payment and the other variables

Appendix F5: The relationships between type of project and time and cost variables

Appendix F6: The relationships between type of building and time and cost variables

Appendix F7: The relationships among time and cost variables

Table F1.1 Nature of client business versus procurement route (corrected)

Nature of client business	Procurement route			Row total
	Traditional	Design and build	Partnering	
Local authority	81 80.2%	14 13.9%	6 5.9%	101 100%
Retailer	12 38.7%	5 16.1%	14 45.2%	31 100%
Financial institution	11 55.0%	3 15.0%	6 30.0%	20 100%
Industrial	15 42.9%	9 25.7%	11 31.4%	35 100%
Property developer	16 51.6%	7 22.6%	8 25.8%	31 100%
Column total Percentage	135 61.9%	38 17.4%	45 20.6%	218 100%

Pearson Chi-Square = 36.397 (Cramer's V = 0.289); probability < 0.0005
Cells with expected frequency < 5 = 2 of 15 (13%)

Table F1.2 The results of Kruskal-Wallis test to investigate the relationship between type of client and project overrun duration

Type of client	Frequency	Mean rank
Local authority	71	61.70
Retailer	10	54.00
Financial institution	13	60.92
Industrial	14	68.61
Property developer	16	67.31
Total	124	

Chi-square = 1.334, $p = 0.856$

Table F1.3 Type of client versus project overbudget

Type of client	Cost outcome		Row total
	On or under budget	Overbudget	
Local authority	48 47.5%	53 52.5%	101 100%
Retailer	20 66.7%	10 33.3%	30 100%
Financial Institution	13 65.0%	7 35.0%	20 100%
Industrial	17 48.6%	18 51.4%	35 100%
Property developer	16 50.0%	16 50.0%	32 100%
Column total Percentage	114 52.3%	104 47.7%	218 100%

Pearson Chi-Square = 4.961 (Cramer's V = 0.151); probability = 0.291
Cells with expected frequency < 5 = 0 of 10 (0%)

Table F1.4 Nature of client business versus method of contractor selection (corrected)

Nature of client business	Method of contractor selection		Row total
	Competitive tendering	Negotiation	
Local authority	60 93.8%	4 6.3%	64 100%
Retailer	7 41.2%	10 58.8%	17 100%
Financial institution	3 42.9%	4 57.1%	7 100%
Industrial	7 58.3%	5 41.7%	12 100%
Property developer	9 45.0%	11 55.5%	20 100%
Column total Percentage	86 71.7%	34 28.3%	120 100%

Pearson Chi-Square = 34.070 (Cramer's V = 0.533); probability < 0.0005
Cells with expected frequency < 5 = 3 of 10 (30%)

Table F1.5 Nature of client business versus method of contractor payment

Nature of client business	Method of contractor payment			Row total
	Lump sum	Unit price	Cost reimbursement	
Local authority	51 73.9%	12 17.4%	6 8.7%	69 100%
Retailer	12 57.1%	3 14.3%	6 28.6%	21 100%
Financial institution	7 70.0%	2 20.0%	1 10.0%	10 100%
Industrial	8 53.3%	5 33.3%	2 13.3%	15 100%
Property developer	16 69.6%	3 13.0%	4 17.4%	23 100%
Column total Percentage	94 68.1%	25 18.1%	19 13.8%	138 100%

Pearson Chi-Square = 8.615 (Cramer's V = 0.177); probability = 0.376
Cells with expected frequency < 5 = 8 of 15 (53%)

Table F1.6 Nature of client business versus method of contractor payment (corrected)

Nature of client business	Method of contractor payment		Row total
	Lump sum	Cost reimbursement	
Local authority	51 89.5%	6 10.5%	57 100%
Retailer	12 66.7%	6 33.3%	18 100%
Financial institution	7 87.5%	1 12.5%	8 100%
Industrial	8 80.0%	2 20.0%	10 100%
Property developer	16 80.0%	4 20.0%	20 100%
Column total Percentage	94 83.2%	19 16.8%	113 100%

Pearson Chi-Square = 5.447 (Cramer's V = 0.220); probability = 0.244
Cells with expected frequency < 5 = 4 of 10 (40%)

Table F2.1 Procurement route versus type of project (corrected)

Procurement route	Type of project			Row total
	New build	Refurbishment	Extension to existing premises	
Traditional	71 52.2%	45 33.1%	20 14.7%	136 100%
Design and build	35 89.7%	2 5.1%	2 5.1%	39 100%
Partnering	27 60.0%	12 26.7%	6 13.3%	45 100%
Column total Percentage	133 60.5%	59 26.8%	28 12.7%	220 100%

Pearson Chi-Square = 18.103 (Cramer's V = 0.203); probability = 0.001
Cells with expected frequency < 5 = 1 of 9 (11%)

Table F2.2 Procurement route versus type of building (corrected)

Procurement route	Type of building					Row total
	Public	Office	Retail	Residential	Industrial	
Traditional	61 45.2%	33 24.4%	6 4.4%	26 19.3%	9 6.7%	135 100%
Design and build	8 20.5%	8 20.5%	5 12.8%	7 17.9%	11 28.2%	39 100%
Partnering	8 17.8%	14 31.1%	13 28.9%	2 4.4%	8 17.8%	45 100%
Column total Percentage	77 35.2%	55 25.1%	24 11.0%	35 16.0%	28 12.8%	219 100%

Pearson Chi-Square = 46.488 (Cramer's V = 0.326); probability < 0.0005
Cells with expected frequency < 5 = 3 of 15 (20%)

Table F2.3 The results of Kruskal-Wallis test to investigate the relationship between procurement route and project overrun duration

Procurement route	Frequency	Mean rank
Traditional	92	64.63
Design and build	19	59.63
Partnering	11	52.36
Cons. Management	3	73.50
Total	125	

Chi-square = 1.577, $p = 0.665$

Table F2.4 Procurement route versus project overrun (corrected)

Procurement route	Time outcome		Row total
	On or before schedule	Overrun	
Traditional	41 30.4%	94 69.6%	135 100%
Design and build	20 51.3%	19 48.7%	39 100%
Partnering	33 73.3%	12 26.7%	45 100%
Column total Percentage	94 42.9%	125 57.1%	219 100%

Pearson Chi-Square = 26.782 (Cramer's V = 0.350); probability < 0.0005
Cells with expected frequency < 5 = 0 of 6 (0%)

Table F2.5 The results of Kruskal-Wallis test to investigate the relationship between procurement route and overbudget cost

Procurement route	Frequency	Mean rank
Traditional	68	46.14
Design and build	16	48.44
Partnering	9	62.61
Cons. Management	4	69.25
Total	97	

Chi-square = 4.895, $p = 0.180$

Table F2.6 Procurement route versus project overbudget (corrected)

Procurement route	Cost outcome		Row total
	On or under budget	Overbudget	
Traditional	61 45.5%	73 54.5%	134 100%
Design and build	21 53.8%	18 46.2%	39 100%
Partnering	33 75.0%	11 25.0%	44 100%
Column total Percentage	115 53.0%	102 47.0%	217 100%

Pearson Chi-Square = 11.568 (Cramer's V = 0.231); probability =0.003
Cells with expected frequency < 5 = 0 of 6 (0%)

Table F2.7 Procurement route versus method of contractor selection (corrected)

Procurement route	Method of contractor selection		Row total
	Competitive tendering	Negotiation	
Traditional	75 92.6%	6 7.4%	81 100%
Design and build	8 66.7%	4 33.3%	12 100%
Partnering	3 11.5%	23 88.5%	26 100%
Column total Percentage	86 72.3%	33 27.7%	119 100%

Pearson Chi-Square = 64.731 (Cramer's V = 0.738); probability < 0.0005
Cells with expected frequency < 5 = 1 of 6 (17%)

Table F2.8 Procurement route versus method of contractor payment (corrected)

Procurement route	Method of contractor selection			Row total
	Lump sum	Unit price	Cost reimbursement	
Traditional	63 75.0%	17 20.2%	4 4.8%	84 100%
Design and build	18 85.7%	2 9.5%	1 4.8%	21 100%
Partnering	12 40.0%	6 20.0%	12 40.0%	30 100%
Column total Percentage	93 68.9%	25 18.5%	17 12.6%	135 100%

Pearson Chi-Square = 29.048 (Cramer's V = 0.328); probability < 0.0005
Cells with expected frequency < 5 = 3 of 9 (33%)

Table F3.1 Method of contractor selection versus type of project (corrected)

Method of contractor Selection	Type of project		Row total
	New build	Refurbishment and extension	
Competitive tendering	51 58.6%	36 41.4%	87 100%
Two-stage competitive tendering	10 50.0%	10 50.0%	20 100%
Negotiation	27 79.4%	7 20.6%	34 100%
Column total Percentage	88 62.4%	53 37.6%	141 100%

Pearson Chi-Square = 6.035 (Cramer's V = 0.207); probability = 0.049
Cells with expected frequency < 5 = 0 of 6 (0%)

Table F3.2 Method of contractor selection versus type of building (corrected)

Method of contractor Selection	Type of building					Row total
	Public	Office	Retail	Residential	Industrial	
Competitive methods	50 46.7%	24 22.4%	10 9.3%	13 12.1%	10 9.3%	107 100%
Negotiation	4 11.8%	14 41.2%	8 23.5%	4 11.8%	4 11.8%	34 100%
Column total Percentage	54 38.3%	38 27.0%	18 12.8%	17 12.1%	14 9.9%	141 100%

Pearson Chi-Square = 15.822 (Cramer's V = 0.335); probability = 0.003
Cells with expected frequency < 5 = 3 of 10 (30%)

Table F3.3 The results of Kruskal-Wallis test to investigate the relationship between method of contractor selection and planned project duration

Method of contractor selection	Frequency	Mean rank
Competitive tendering	84	66.80
Two-stage comp. tend.	19	76.03
Negotiation	34	70.51
Total	137	

Chi-square = 0.911, $p = 0.634$

Table F3.4 The results of Kruskal-Wallis test to investigate the relationship between method of contractor selection and overrun duration

Method of contractor selection	Frequency	Mean rank
Competitive tendering	60	40.73
Two-stage comp. tend.	12	41.21
Negotiation	10	46.45
Total	82	

Chi-square = 0.506, $p = 0.776$

Table F3.5 The results of Kruskal-Wallis test to investigate the relationship between method of contractor selection and overbudget cost

Method of contractor selection	Frequency	Mean rank
Competitive tendering	43	27.80
Two-stage comp. tend.	8	39.75
Negotiation	9	35.17
Total	60	

Chi-square = 3.923, $p = 0.141$

Table F3.6 Method of contractor selection versus method of contractor payment

Method of contractor Selection	Method of contractor payment: Lump sum	Unit price	Cost reimbursement	Row total
Competitive tendering	64 75.3%	17 20.0%	4 4.7%	85 100%
Negotiation	17 51.5%	4 12.1%	12 36.4%	33 100%
Column total Percentage	81 68.6%	21 17.8%	16 13.6%	118 100%

Pearson Chi-Square = 20.357 (Cramer's V = 0.415); probability < 0.0005
Cells with expected frequency < 5 = 1 of 6 (17%)

Table F4.1 Method of contractor payment versus type of project

Method of contractor Payment	Type of project			Row total
	New build	Refurbishment	Extension to existing premises	
Lump sum	61 64.2%	25 26.3%	9 9.5%	95 100%
Unit price	12 48.0%	11 44.0%	2 8.0%	25 100%
Cost reimbursement	15 78.9%	2 10.5%	2 10.5%	19 100%
Column total Percentage	88 63.3%	38 27.3%	13 9.4%	139 100%

Pearson Chi-Square = 6.289 (Cramer's V = 0.150); probability = 0.179
Cells with expected frequency < 5 = 2 of 9 (22%)

Table F4.2 Method of contractor payment versus type of project (corrected)

Method of contractor Payment	Type of project		Row total
	New build	Refurbishment and extension	
Lump sum	61 64.2%	34 35.8%	95 100%
Unit price	12 48.0%	13 52.0%	25 100%
Cost reimbursement	15 78.9%	4 21.1%	19 100%
Column total Percentage	88 63.3%	51 36.7%	139 100%

Pearson Chi-Square = 4.556 (Cramer's V = 0.181); probability = 0.102
Cells with expected frequency < 5 = 0 of 6 (0%)

Table F4.3 Method of contractor payment (lump sum and unit price) versus type of building (corrected)

Method of contractor Payment	Type of building					Row total
	Public	Office	Retail	Residential	Industrial	
Lump sum	38 40.0%	27 28.4%	10 10.5%	14 14.7%	6 6.3%	95 100%
Unit price	10 40.0%	7 28.0%	2 8.0%	2 8.0%	4 16.0%	25 100%
Column total Percentage	48 40.0%	34 28.3%	12 10.0%	16 13.3%	10 8.3%	120 100%

Pearson Chi-Square = 3.029 (Cramer's V = 0.159); probability = 0.553
Cells with expected frequency < 5 = 3 of 10 (30%)

Table F4.4 Method of contractor payment (lump sum and cost reimbursement) versus type of building (corrected)

Method of contractor Payment	Type of building					Row total
	Public	Office	Retail	Residential	Industrial	
Lump sum	38 40.0%	27 28.4%	10 10.5%	14 14.7%	6 6.3%	95 100%
Cost reimbursement	4 21.1%	5 26.3%	5 26.3%	1 5.3%	4 21.1%	19 100%
Column total Percentage	42 36.8%	32 28.1%	15 13.2%	15 13.2%	10 8.8%	114 100%

Pearson Chi-Square = 9.568 (Cramer's V = 0.290); probability = 0.048
Cells with expected frequency < 5 = 3 of 10 (30%)

Table F4.5 The results of Kruskal-Wallis test to investigate the relationship between method of contractor payment and planned project duration

Method of contractor payment	Frequency	Mean rank
Lump sum	92	68.18
Unit price	25	68.28
Cost reimbursement	19	70.34
Total	136	

Chi-square = 0.049, p = 0.976

Table F4.6 The results of Kruskal-Wallis test to investigate the relationship between method of contractor payment and overrun duration

Method of contractor payment	Frequency	Mean rank
Lump sum	60	41.45
Unit price	13	43.85
Cost reimbursement	9	38.44
Total	82	

Chi-square = 0.280, $p = 0.869$

Table F4.7 The results of Kruskal-Wallis test to investigate the relationship between method of contractor payment and overbudget cost

Method of contractor payment	Frequency	Mean rank
Lump sum	46	29.60
Unit price	9	29.17
Cost reimbursement	6	44.50
Total	61	

Chi-square = 3.862, $p = 0.145$

Table F5.1 Type of project versus project overrun

Type of project	Time outcome		Row total
	On or before schedule	Overrun	
New build	60 44.4%	75 55.6%	135 100%
Refurbishment	27 45.8%	32 54.2%	59 100%
Extension to existing premises	9 31.0%	20 69.0%	29 100%
Column total Percentage	96 43.0%	127 57.0%	223 100%

Pearson Chi-Square = 1.992 (Cramer's V = 0.095); probability = 0.369
Cells with expected frequency < 5 = 0 of 6 (0%)

Table F5.2 The results of Kruskal-Wallis test to investigate the relationship between type of project and overrun duration

Type of project	Frequency	Mean rank
New build	72	64.00
Refurbishment	32	57.66
Extension to existing premises	20	64.85
Total	124	

Chi-square = 0.806, $p = 0.668$

Table F5.3 Type of project versus project overbudget

Type of project	Cost outcome		Row total
	On or under budget	Overbudget	
New build	72 53.3%	63 46.7%	135 100%
Refurbishment	30 52.6%	27 47.4%	57 100%
Extension to existing premises	13 44.8%	16 55.2%	29 100%
Column total Percentage	115 52.0%	106 48.0%	221 100%

Pearson Chi-Square = 0.703 (Cramer's V = 0.056); probability = 0.704
Cells with expected frequency < 5 = 0 of 6 (0%)

Table F5.4 The results of Kruskal-Wallis test to investigate the relationship between type of project and overbudget cost

Type of project	Frequency	Mean rank
New build	56	51.71
Refurbishment	26	41.25
Extension to existing premises	15	52.30
Total	97	

Chi-square = 2.704, $p = 0.259$

Table F6.1 The results of Kruskal-Wallis test to investigate the relationship between type of building and overrun duration

Type of building	Frequency	Mean rank
Public	51	60.64
Office	29	67.52
Retail	6	48.58
Residential	26	67.98
Industrial	12	53.38
Total	124	

Chi-square = 3.033, $p = 0.552$

Table F6.2 The results of Kruskal-Wallis test to investigate the relationship between type of building and overbudget cost

Type of building	Frequency	Mean rank
Public	41	43.28
Office	27	58.48
Retail	5	70.30
Residential	17	40.68
Industrial	7	50.93
Total	97	

Chi-square = 9.161, $p = 0.057$

Table F7.1 The results of Mann-Whitney test to investigate the relationship between planned project duration and project overrun

Time outcome	Frequency	Mean rank
On or before schedule	95	112.47
Overrun	125	109.00
Total	220	

Asymptote significant $p = 0.687$

Table F7.2 The results of Mann-Whitney test to investigate the relationship between planned project duration and project overbudget

Cost outcome	Frequency	Mean rank
On or under budget	113	108.64
Overbudget	104	109.39
Total	217	

Asymptote significant $p = 0.929$

Table F7.3 The results of Mann-Whitney test to investigate the relationship between project overrun and overbudget cost

Time outcome	Frequency	Mean rank
On or before schedule	15	51.90
Overrun	82	48.47
Total	97	

Asymptote significant $p = 0.664$

Table F7.4 The results of Mann-Whitney test to investigate the relationship between overrun duration and project overbudget

Cost outcome	Frequency	Mean rank
On or under budget	38	54.05
Overbudget	85	65.55
Total	123	

Asymptote significant $p = 0.095$

Table F7.5 The results of Mann-Whitney test to investigate the relationship between tender sum and project overbudget

Cost outcome	Frequency	Mean rank
On or under budget	113	112.63
Overbudget	103	103.97
Total	216	

Asymptote significant $p = 0.309$

Appendix G:

Principal Components Analysis (PCA) for Combining Independent Variables

Appendix G1: Principal components analysis for combining independent variables of architects' assessment of client performance

Appendix G2: Principal components analysis for combining independent variables of contractors' assessment of client performance

Appendix G3: Principal components analysis for combining independent variables of clients' assessment of architect performance

Appendix G4: Principal components analysis for combining independent variables of contractors' assessment of architect performance

Appendix G5: Principal components analysis for combining independent variables of clients' assessment of contractor performance

Appendix G6: Principal components analysis for combining independent variables of architects' assessment of contractor performance

Table G1.1 Eigen values, percentage and total variance explained of PCA of respondent attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	2.408	48.161	48.161
2	0.994	19.882	
3	0.750	15.005	
4	0.510	10.208	
5	0.337	6.745	

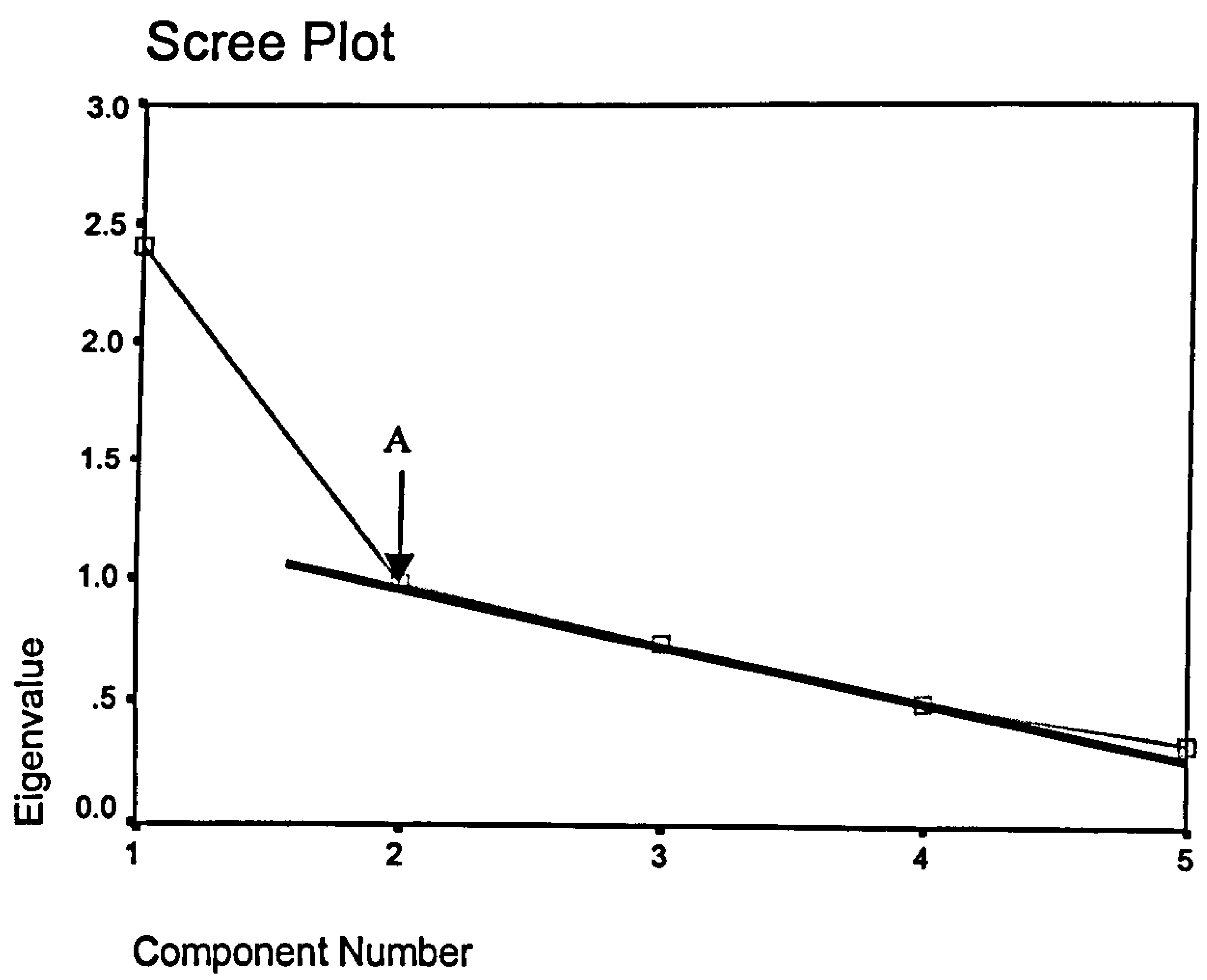

Figure G1.1 Scree plot of components' eigen values based on the PCA of respondent attributes

Table G1.2 Structure matrix of PCA of respondent attributes

Attributes	Component
	1
RSSATCL	-0.672
RSCLI1	**0.793**
RSCLI2	**0.789**
RSCLI6	0.639
RSCLI7	0.545

Note: KMO = 0.673
Chi-square = 59.288 (degree of freedom = 10; $p < 0.0005$)

Table G1.3 Eigen values, percentage and total variance explained of PCA of client performance attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	7.060	41.528	41.528
2	1.867	10.984	52.512
3	1.360	8.001	60.513
4	1.268	7.458	67.971
5	1.015	5.970	73.942
6	0.964	5.672	
7	0.749	4.407	
8	0.698	4.107	
9	0.567	3.335	
10	0.344	2.022	
11	0.313	1.842	
12	0.297	1.746	
13	0.176	1.035	
14	0.146	0.857	

Note: Components 15-17 are not shown

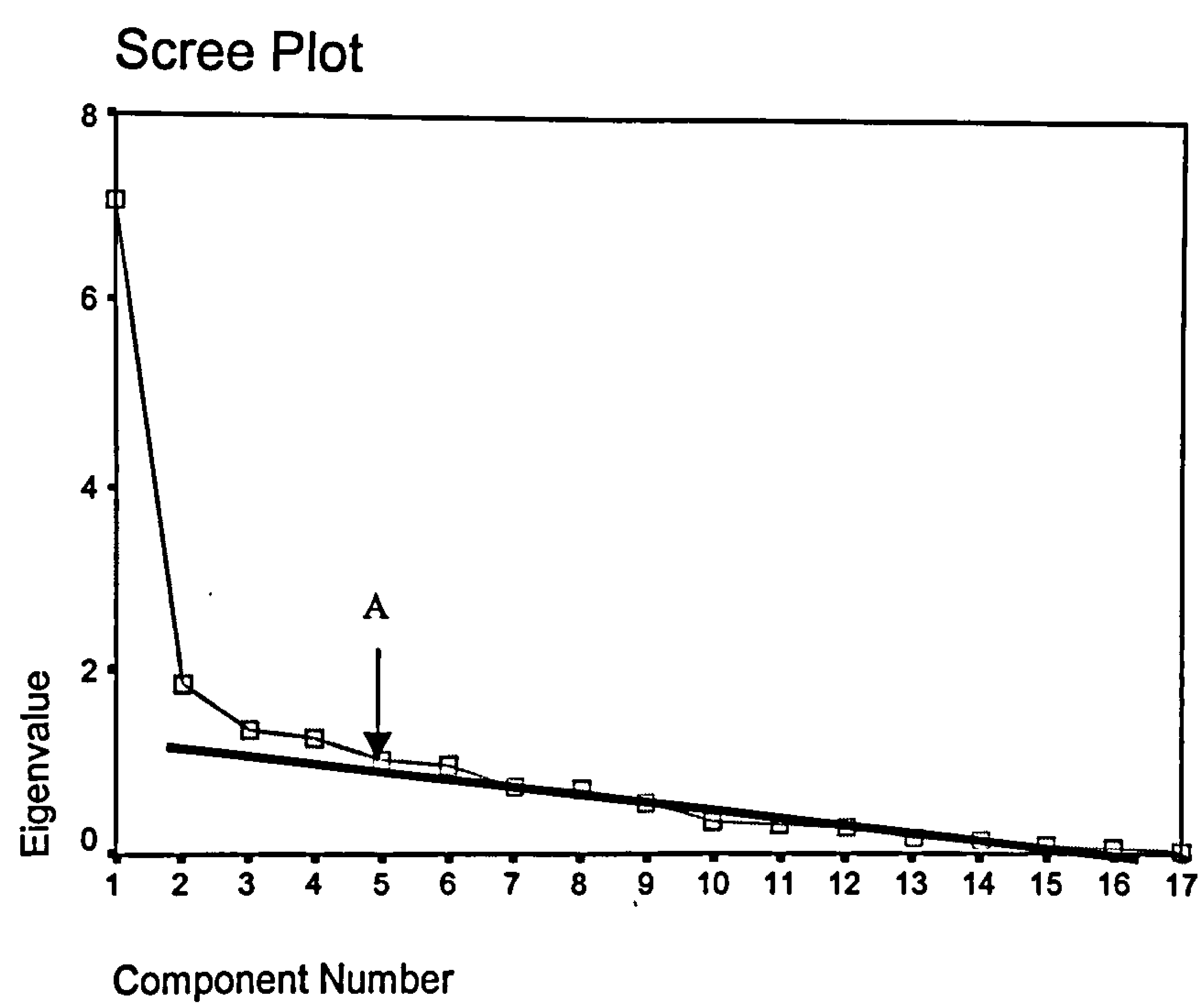

Figure G1.2 Scree plot of components' eigen values based on the PCA of client performance attributes

Table G1.4 Component correlation matrix based on the PCA of client performance attributes

Component	1	2	3	4	5
1	1.000	0.520	0.477	0.025	0.365
2		1.000	0.271	-0.042	0.424
3			1.000	0.103	0.038
4				1.000	-0.216
5					1.000

Table G1.5 Structure matrix of PCA of client performance attributes

Attributes	Component				
	1	2	3	4	5
CLDEPWL	0.660	0.531	0.616		
CLORGST				0.569	
CLCOMCH				0.777	
CLATTFI	0.587				
CLATTTY	0.511		**0.929**		
CLATTSI	0.548		**0.899**		
CLATTPP	**0.826**	0.586	0.590		
CLATTSC	**0.926**				
CLATTBU	**0.936**				
CLATTQU	**0.825**				
CLATTLI					
CLATTPM	0.545	**0.904**			
CLATTAU	0.522	**0.927**			
CLATTQA	0.640	**0.730**			0.529
CLATTQE		**0.785**			
CLATTWR					0.833
CLEVAAR		0.522		-0.508	0.673

Note: KMO = 0.794
Chi-square = 649.779 (degree of freedom = 136; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed

Table G2.1 Eigen values, percentage and total variance explained of PCA of respondent attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	2.080	41.608	41.608
2	1.284	25.684	67.292
3	0.738	14.761	
4	0.523	10.465	
5	0.374	7.482	

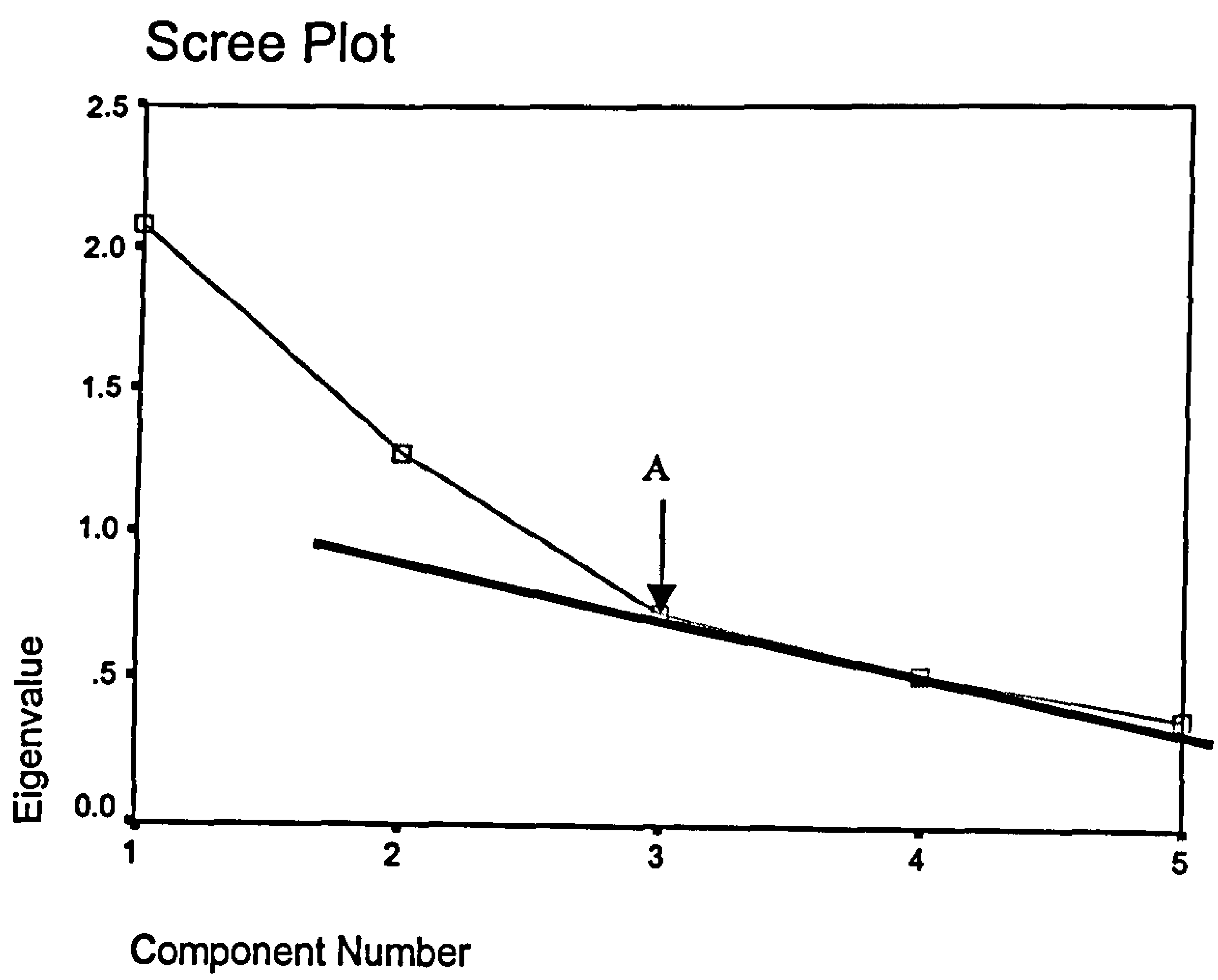

Figure G2.1 Scree plot of components' eigen values based on the PCA of respondent attributes

Table G2.2 Structure matrix of PCA of respondent attributes

Attributes	Component	
	1	2
RSSATCL		0.737
RSCLI1	0.810	
RSCLI2	0.724	-0.616
RSCLI6	0.764	
RSCLI7		0.742

Note: KMO = 0.619
Chi-square = 49.026 (degree of freedom = 10; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed
Correlation coefficient between first and second components was –0.216

Table G2.3 Eigen values, percentage and total variance explained of PCA of client performance attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	7.769	45.700	45.700
2	1.873	11.019	56.719
3	1.510	8.880	65.599
4	1.222	7.186	72.786
5	1.125	6.618	79.404
6	0.674	3.965	
7	0.591	3.475	
8	0.459	2.698	
9	0.440	2.587	
10	0.339	1.997	
11	0.321	1.890	
12	0.231	1.357	
13	0.146	0.862	
14	0.133	0.784	

Note: Components 15-17 are not shown

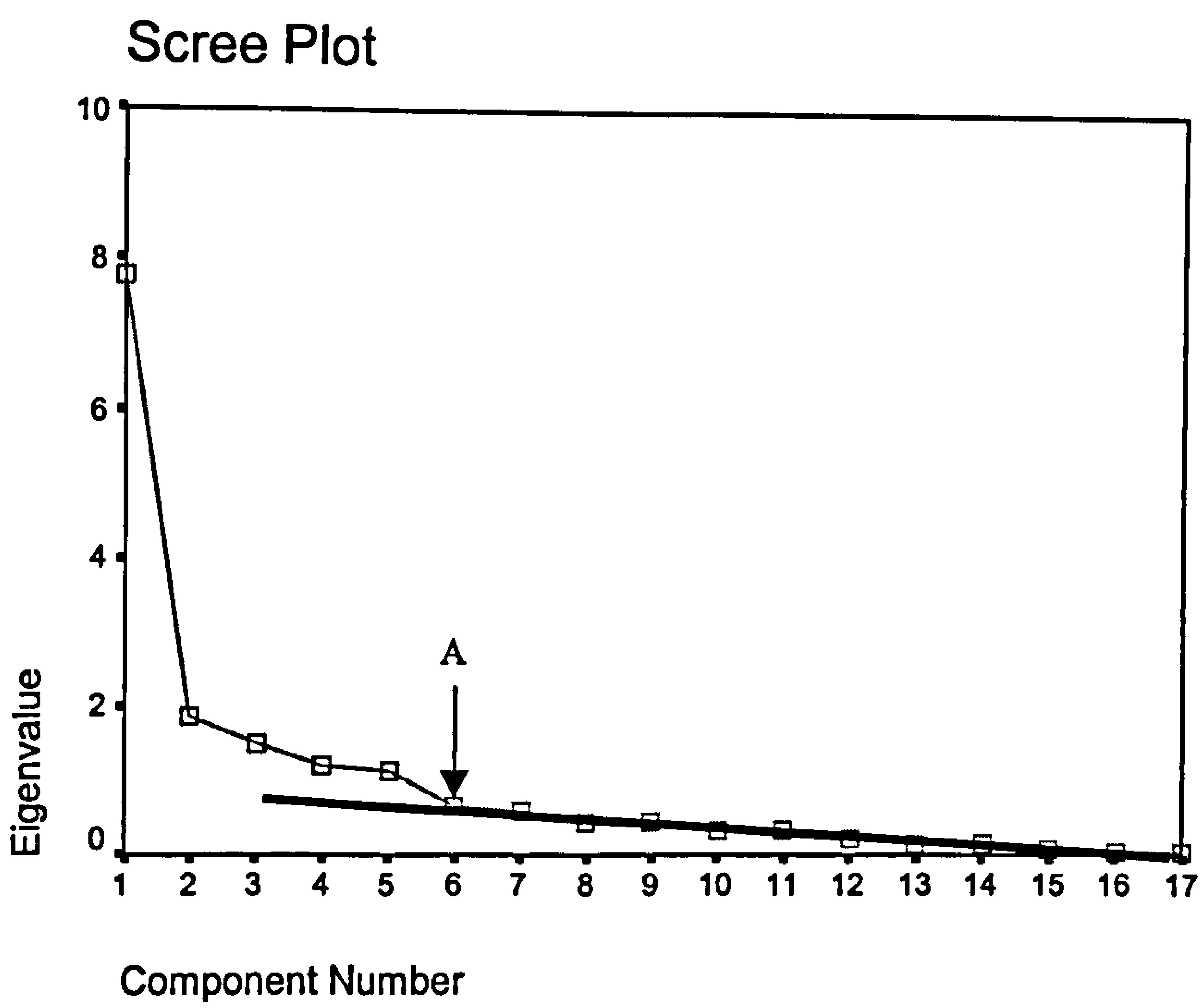

Figure G2.2 Scree plot of components' eigen values based on the PCA of client performance attributes

Table G2.4 Component correlation matrix based on the PCA of client performance attributes

Component	1	2	3	4	5
1	1.000	0.472	0.363	0.349	0.135
2		1.000	0.217	0.261	0.259
3			1.000	0.103	0.140
4				1.000	0.111
5					1.000

Table G2.5 Structure matrix of PCA of client performance attributes

Attributes	Component				
	1	2	3	4	5
CLDEPWL		**0.805**			
CLORGST					0.726
CLCOMCH					0.819
CLATTFI				**0.902**	
CLATTTY	0.546	**0.895**			
CLATTSI	0.566	**0.916**			
CLATTPP	**0.866**	0.532			
CLATTSC	**0.932**	0.520			
CLATTBU	**0.923**	0.529			
CLATTQU	**0.862**	0.552			
CLATTLI				**0.852**	
CLATTPM	**0.861**		0.560		
CLATTAU	**0.888**		0.534		
CLATTQA	0.564		0.678		
CLATTQE			0.834		
CLATTWR	0.584	0.736			
CLEVACO			0.763		

Note: KMO = 0.824
Chi-square = 738.635 (degree of freedom = 136; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed

Table G3.1 Eigen values, percentage and total variance explained of PCA of respondent attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	4.455	55.689	55.689
2	1.076	13.450	69.139
3	0.757	9.459	
4	0.539	6.732	
5	0.470	5.872	
6	0.358	4.469	
7	0.219	2.732	
8	0.128	1.599	

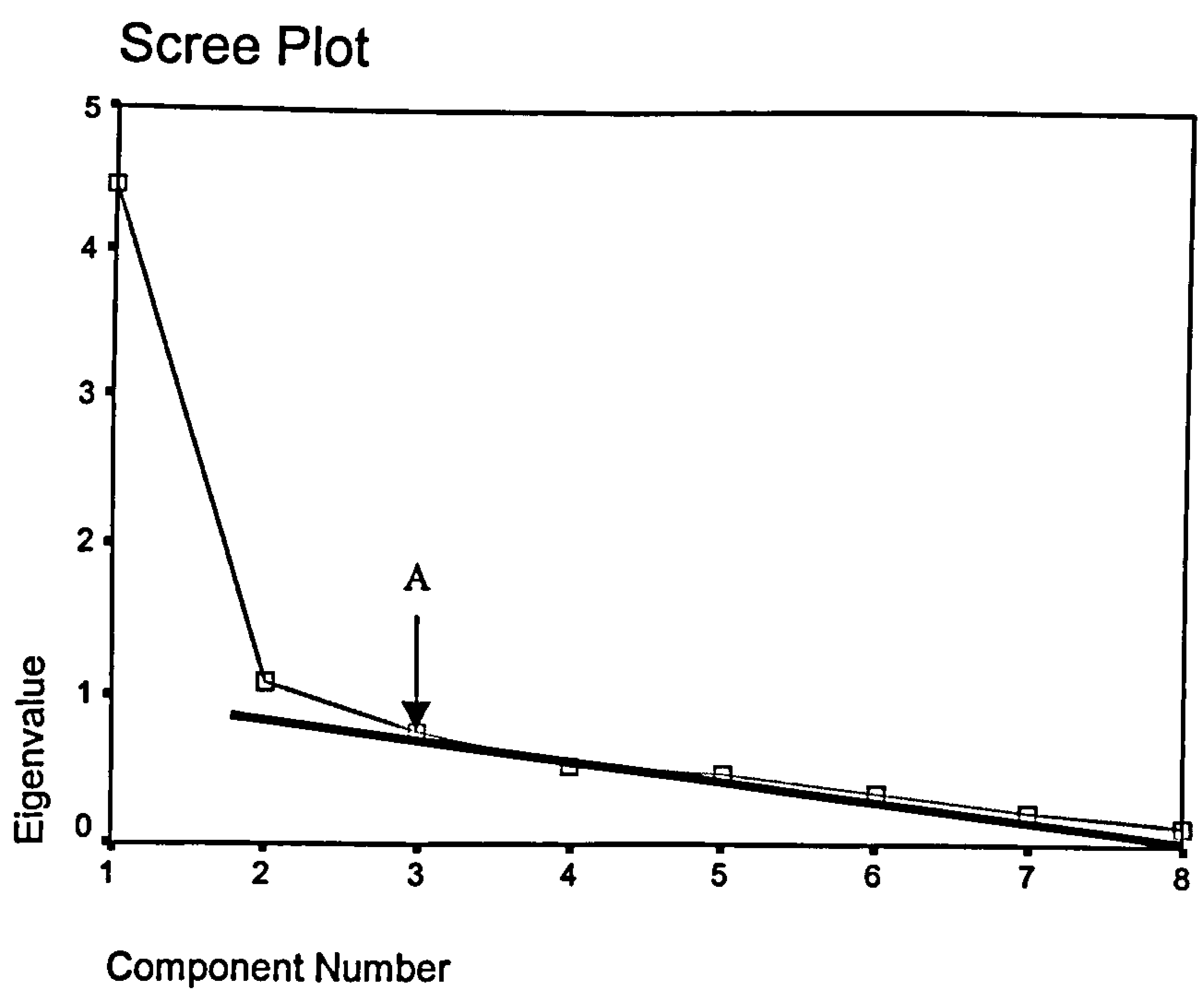

Figure G3.1 Scree plot of components' eigen values based on the PCA of respondent attributes

Table G3.2 Structure matrix of PCA of respondent attributes

Attributes	Component	
	1	2
RSSATAR		-0.818
RSARC1	**0.831**	
RSARC2	**0.854**	
RSARC3	**0.825**	0.597
RSARC4	**0.759**	0.707
RSARC5	0.666	0.559
RSARC6	0.683	0.738
RSARC7	0.740	0.671

Note: KMO = 0.783
Chi-square = 204.098 (degree of freedom = 28; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed
Correlation coefficient between first and second components was 0.520

Table G3.3 Eigen values, percentage and total variance explained of PCA of architect performance attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	**4.662**	**35.860**	**35.860**
2	**1.951**	**15.007**	**50.867**
3	**1.743**	**13.411**	**64.278**
4	0.973	7.488	
5	0.760	5.847	
6	0.696	5.354	
7	0.596	4.584	
8	0.575	4.421	
9	0.385	2.963	
10	0.225	1.734	
11	0.199	1.529	
12	0.124	0.952	
13	0.111	0.852	

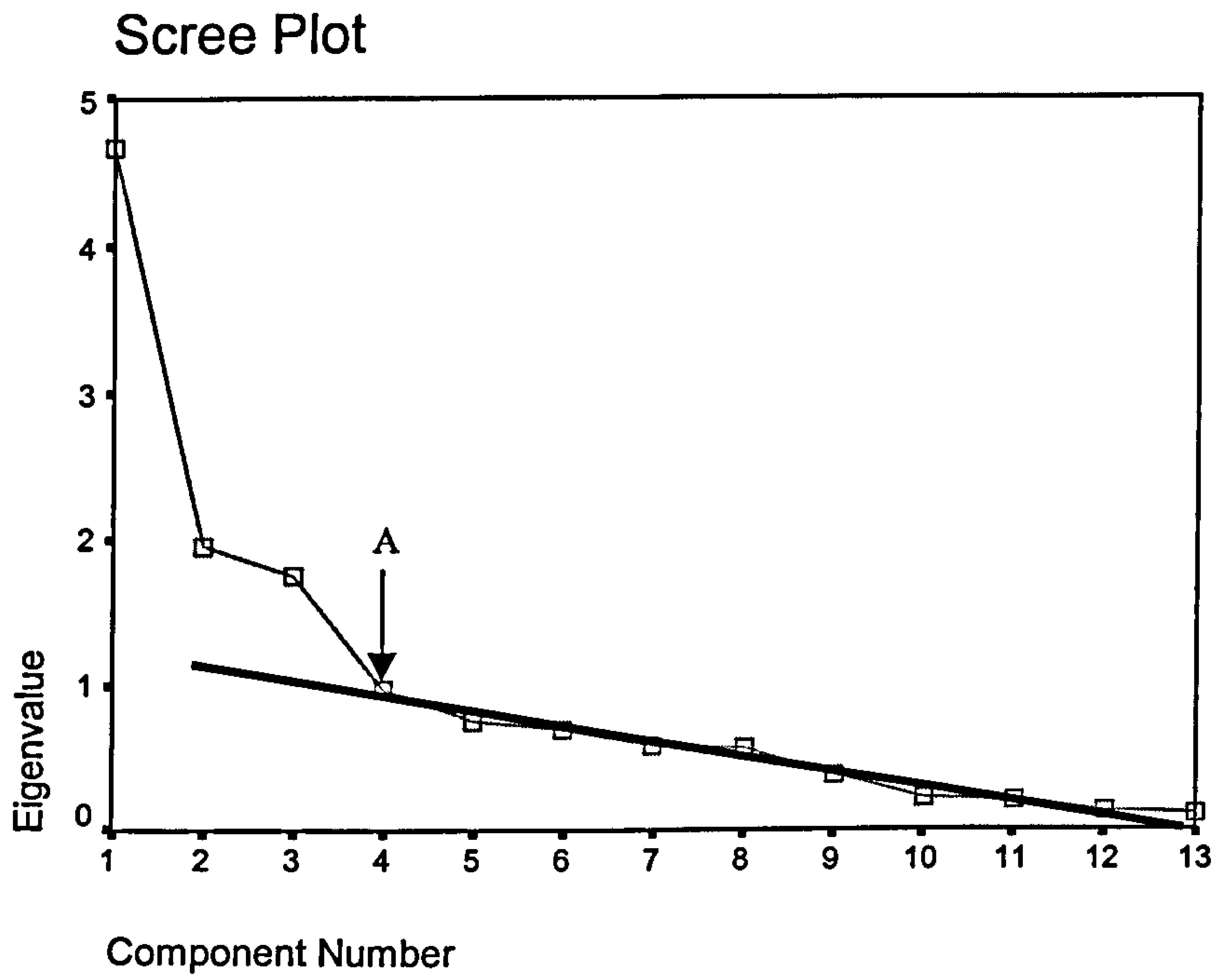

Figure G3.2 Scree plot of components' eigen values based on the PCA of architect performance attributes

Table G3.4 Component correlation matrix based on the PCA of architect performance attributes

Component	**1**	**2**	**3**
1	1.000	0.247	0.014
2		1.000	-0.188
3			1.000

Table G3.5 Structure matrix of PCA of architect performance attributes

Attributes	**Component**		
	1	**2**	**3**
ARWL		0.653	
ARATTFI		0.735	
ARATTTY	0.562	0.639	
ARATTSI	0.658	0.688	
ARATTPP	**0.786**		
ARATTSC	**0.819**		
ARATTBU	**0.778**		
ARATTQU	0.729		
ARATTLI			0.621
ARATTDI			0.745
ARATTSP	0.668		
ARATTQC			0.576
ARATTWR	**0.805**		

Note: KMO = 0.663
Chi-square = 306.291 (degree of freedom = 78; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed

Table G4.1 Eigen values, percentage and total variance explained of PCA of respondent attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	3.922	49.023	49.023
2	1.039	12.989	62.012
3	0.879	10.991	
4	0.729	9.115	
5	0.589	7.363	
6	0.420	5.248	
7	0.233	2.910	
8	0.189	2.361	

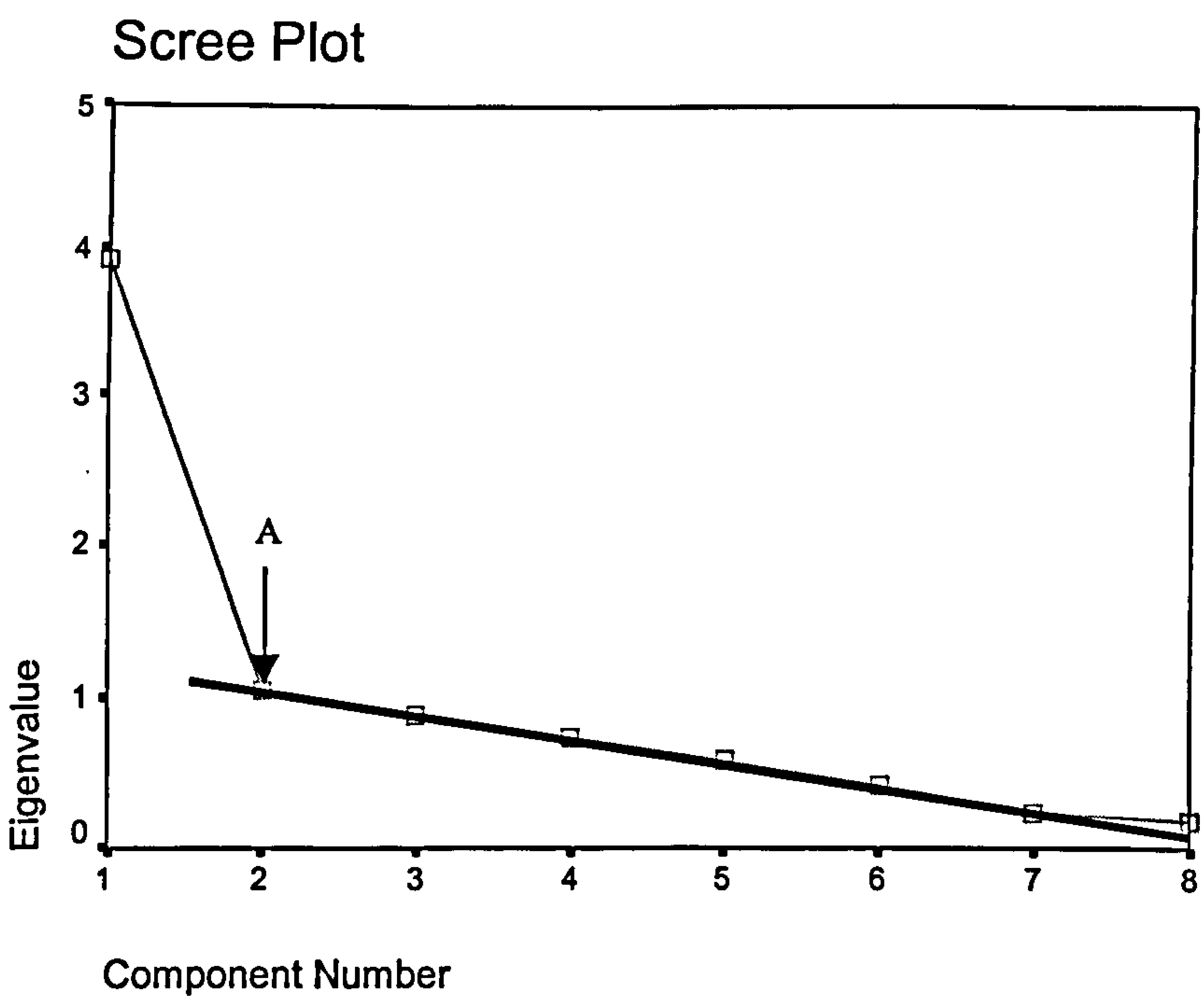

Figure G4.1 Scree plot of components' eigen values based on the PCA of respondent attributes

Table G4.2 Structure matrix of PCA of respondent attributes

Attributes	Component	
	1	2
RSSATAR		
RSARC1		**0.896**
RSARC2	0.621	**0.852**
RSARC3	**0.806**	
RSARC4	0.715	
RSARC5	0.677	
RSARC6	**0.868**	
RSARC7	**0.840**	

Note: KMO = 0.782
Chi-square = 179.821 (degree of freedom = 28; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed
Correlation coefficient between first and second components was 0.484

Table G4.3 Eigen values, percentage and total variance explained of PCA of architect performance attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	4.796	36.896	36.896
2	1.672	12.860	49.756
3	1.335	10.268	60.024
4	1.014	7.800	67.824
5	0.920	7.080	
6	0.708	5.446	
7	0.561	4.313	
8	0.526	4.046	
9	0.489	3.761	
10	0.355	2.728	
11	0.266	2.043	
12	0.213	1.639	
13	0.146	1.120	

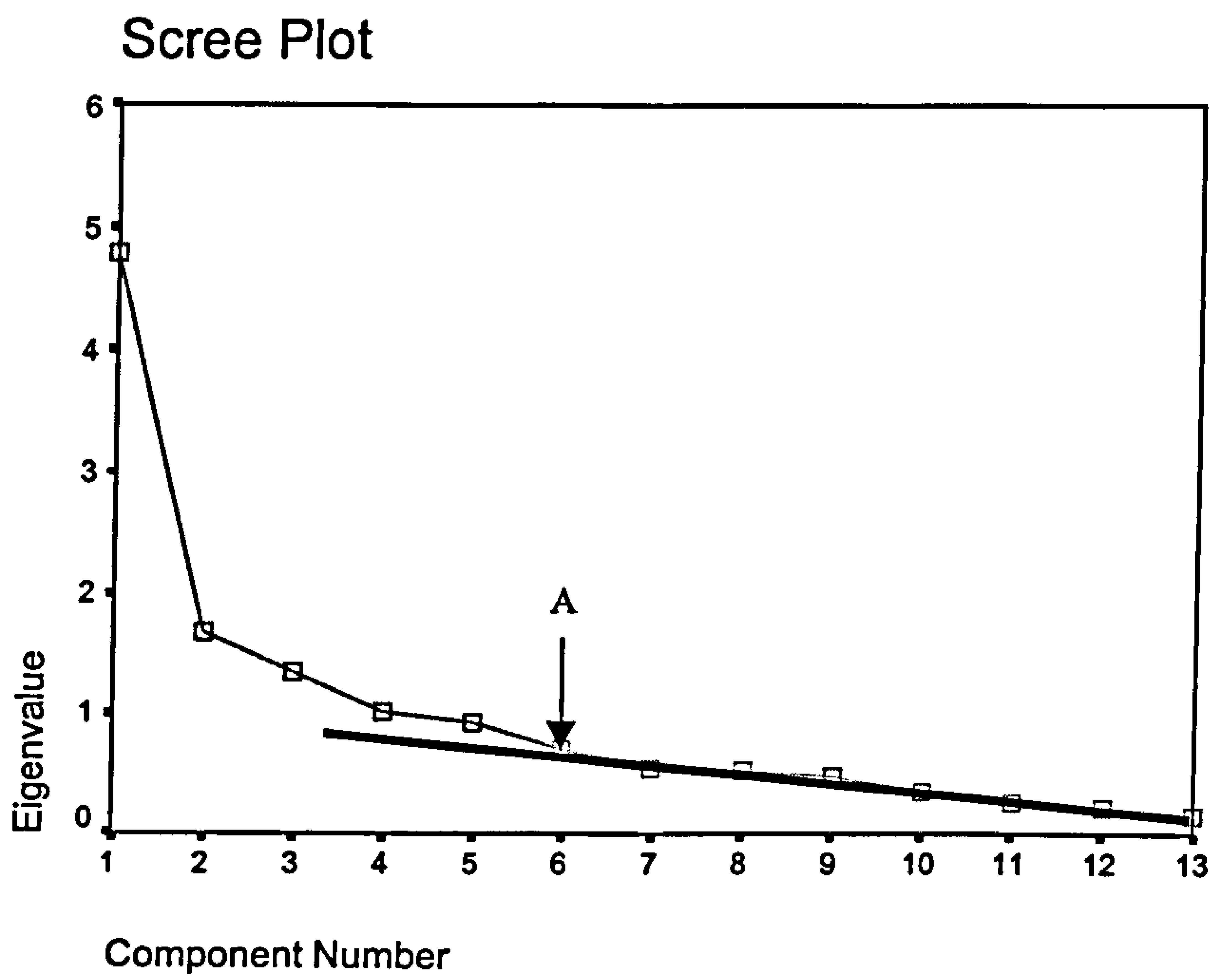

Figure G4.2 Scree plot of components' eigen values based on the PCA of architect performance attributes

Table G4.4 Component correlation matrix based on the PCA of architect performance attributes

Component	1	2	3	4
1	1.000	0.529	0.114	-0.129
2		1.000	0.216	-0.028
3			1.000	-0.052
4				1.000

Table G4.5 Structure matrix of PCA of architect performance attributes

Attributes	Component			
	1	2	3	4
ARWL				0.887
ARATTFI		0.688		
ARATTTY		0.644		
ARATTSI	0.515	0.681		
ARATTPP	0.662	**0.752**		
ARATTSC	**0.897**	0.536		
ARATTBU	**0.873**			
ARATTQU	0.586	0.529		
ARATTLI			0.813	
ARATTDI		**0.758**	0.506	
ARATTSP	0.642			-0.700
ARATTQC	0.691			
ARATTWR			0.556	

Note: KMO = 0.749
Chi-square = 283.999 (degree of freedom = 78; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed

Table G5.1 Eigen values, percentage and total variance explained of PCA of respondent attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	3.264	46.628	46.628
2	1.462	20.879	67.507
3	0.877	12.532	
4	0.501	7.155	
5	0.391	5.592	
6	0.282	4.027	
7	0.223	3.187	

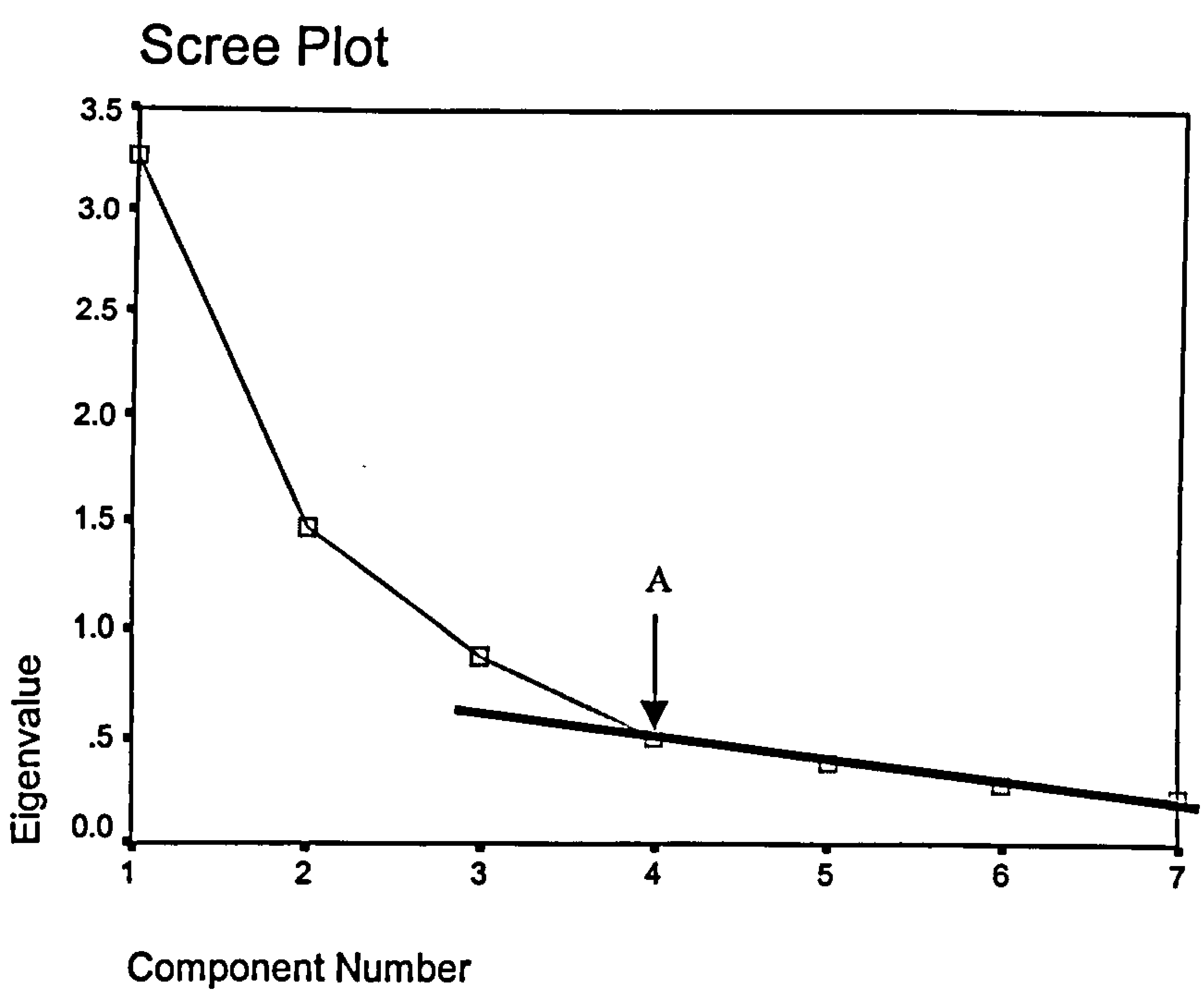

Figure G5.1 Scree plot of components' eigen values based on the PCA of respondent attributes

Table G5.2 Structure matrix of PCA of respondent attributes

Attributes	Component	
	1	2
RSSATCO		
RSCON2		0.825
RSCON3		0.818
RSCON4		0.900
RSCON5	0.839	
RSCON6	0.907	
RSCON7	0.837	

Note: KMO = 0.734
Chi-square = 135.869 (degree of freedom = 21; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed
Correlation coefficient between first and second components was 0.355

Table G5.3 Eigen values, percentage and total variance explained of PCA of contractor performance attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	6.960	34.798	34.798
2	2.689	13.443	48.241
3	1.993	9.966	58.207
4	1.609	8.043	66.249
5	1.146	5.732	71.981
6	0.959	4.794	
7	0.801	4.004	
8	0.669	3.343	
9	0.571	2.854	
10	0.498	2.488	
11	0.449	2.245	
12	0.359	1.795	
13	0.291	1.454	
14	0.254	1.270	
15	0.203	1.013	
16	0.155	0.777	

Note: Components 17-20 are not shown

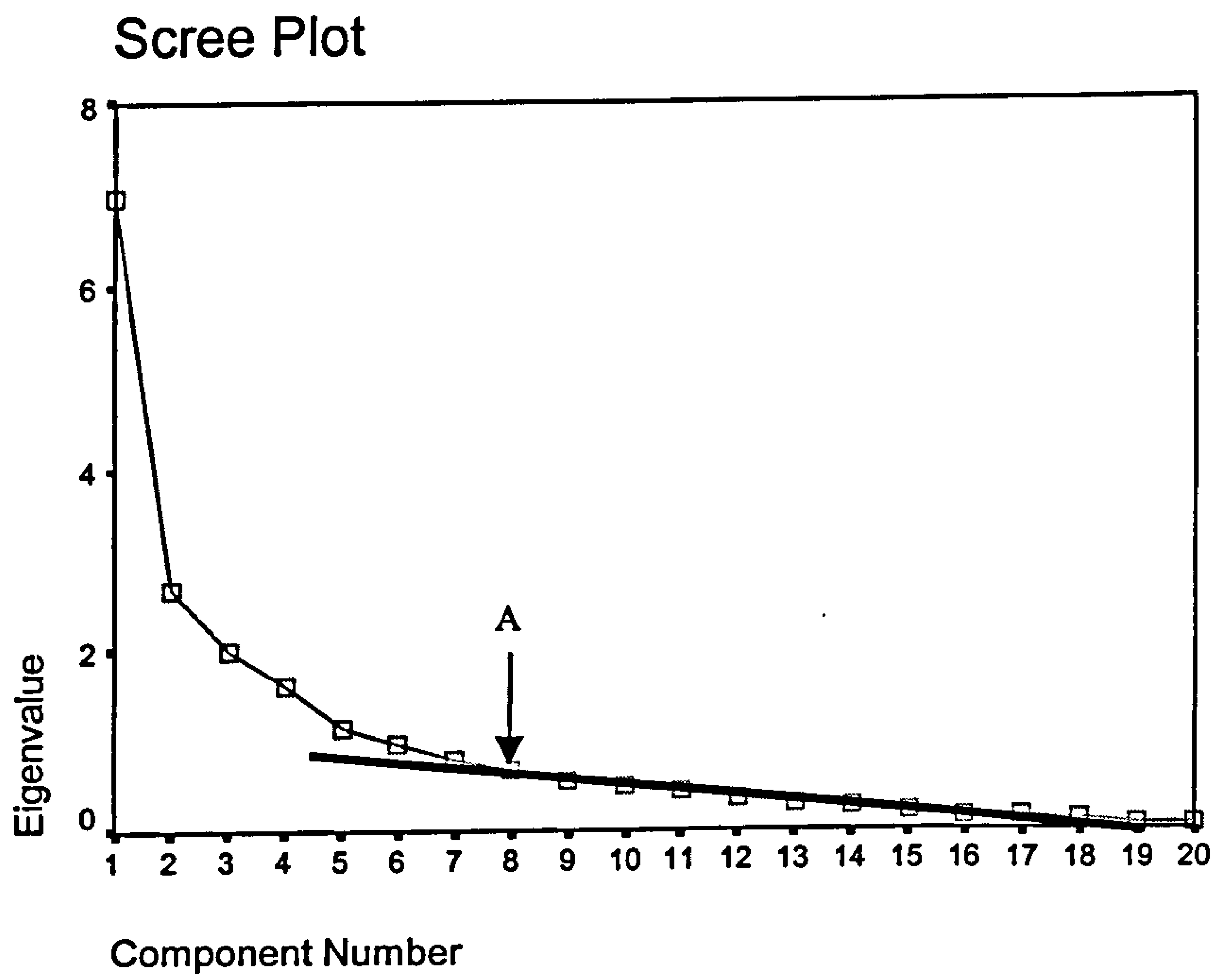

Figure G5.2 Scree plot of components' eigen values based on the PCA of contractor performance attributes

Table G5.4 Component correlation matrix based on the PCA of contractor performance attributes

Component	1	2	3	4	5
1	1.000	0.442	0.291	0.053	0.238
2		1.000	0.168	0.022	0.187
3			1.000	0.344	0.125
4				1.000	0.067
5					1.000

Table G5.5 Structure matrix of PCA of contractor performance attributes

Attributes	Component				
	1	2	3	4	5
COEVACL			0.540		
COWL					0.649
COATTFI		**0.860**			
COATTTY		**0.887**			
COATTSI		**0.890**			
COATTRE			0.645	0.649	
COATTPP	**0.748**	0.572			
COATTSC	**0.787**				
COATTBU	**0.819**	0.539			
COATTQU	**0.782**				
COATTLI					**0.751**
COATTIM					**0.762**
COATTDI			0.740	0.517	
COATTSP		0.563	0.632		
COATTHS	0.537		0.711		
COATTTR	0.553		0.756		
COATTQC	0.728		0.569		
COATTSU				**0.917**	
COATTLA				**0.926**	
COATTWR					0.553

Note: KMO = 0.715
Chi-square = 629.526 (degree of freedom = 190; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed

Table G6.1 Eigen values, percentage and total variance explained of PCA of respondent attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	4.754	67.912	67.912
2	0.656	9.375	
3	0.522	7.460	
4	0.439	6.272	
5	0.318	4.548	
6	0.170	2.424	
7	0.141	2.007	

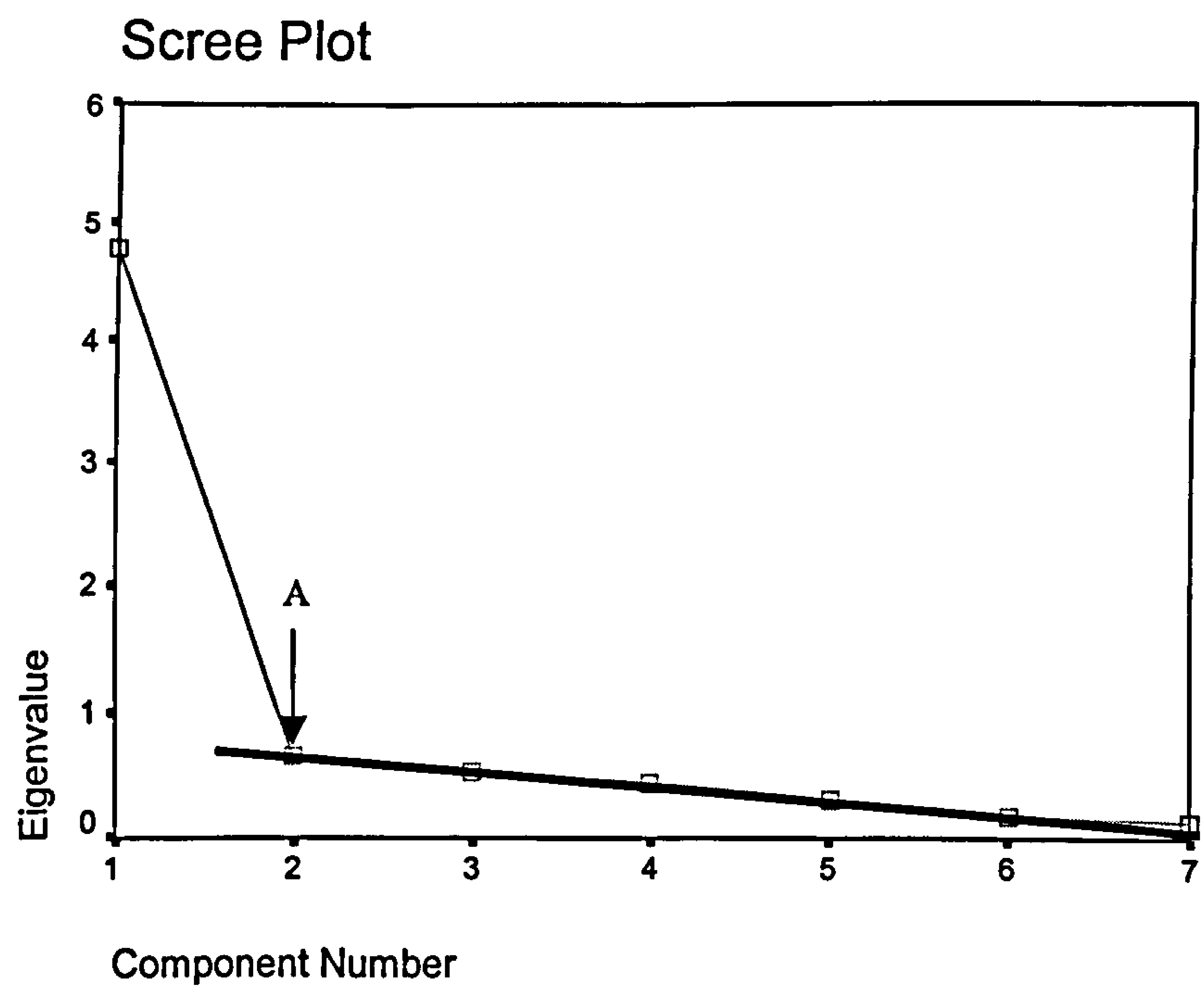

Figure G6.1 Scree plot of components' eigen values based on the PCA of respondent attributes

Table G6.2 Structure matrix of PCA of respondent attributes

Attributes	Component
	1
RSSATCO	-0.712
RSCON2	0.829
RSCON3	0.791
RSCON4	0.877
RSCON5	0.903
RSCON6	0.877
RSCON7	0.762

Note: KMO = 0.874
Chi-square = 259.910 (degree of freedom = 21; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed

Table G6.3 Eigen values, percentage and total variance explained of PCA of contractor performance attributes

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	7.792	38.960	38.960
2	2.058	10.292	49.252
3	1.718	8.592	57.844
4	1.373	6.864	64.708
5	1.301	6.504	71.212
6	1.046	5.228	76.440
7	0.765	3.827	
8	0.733	3.663	
9	0.658	3.288	
10	0.562	2.810	
11	0.474	2.369	
12	0.369	1.843	
13	0.294	1.470	
14	0.263	1.314	
15	0.188	0.940	
16	0.117	0.587	

Note: Components 17-20 are not shown

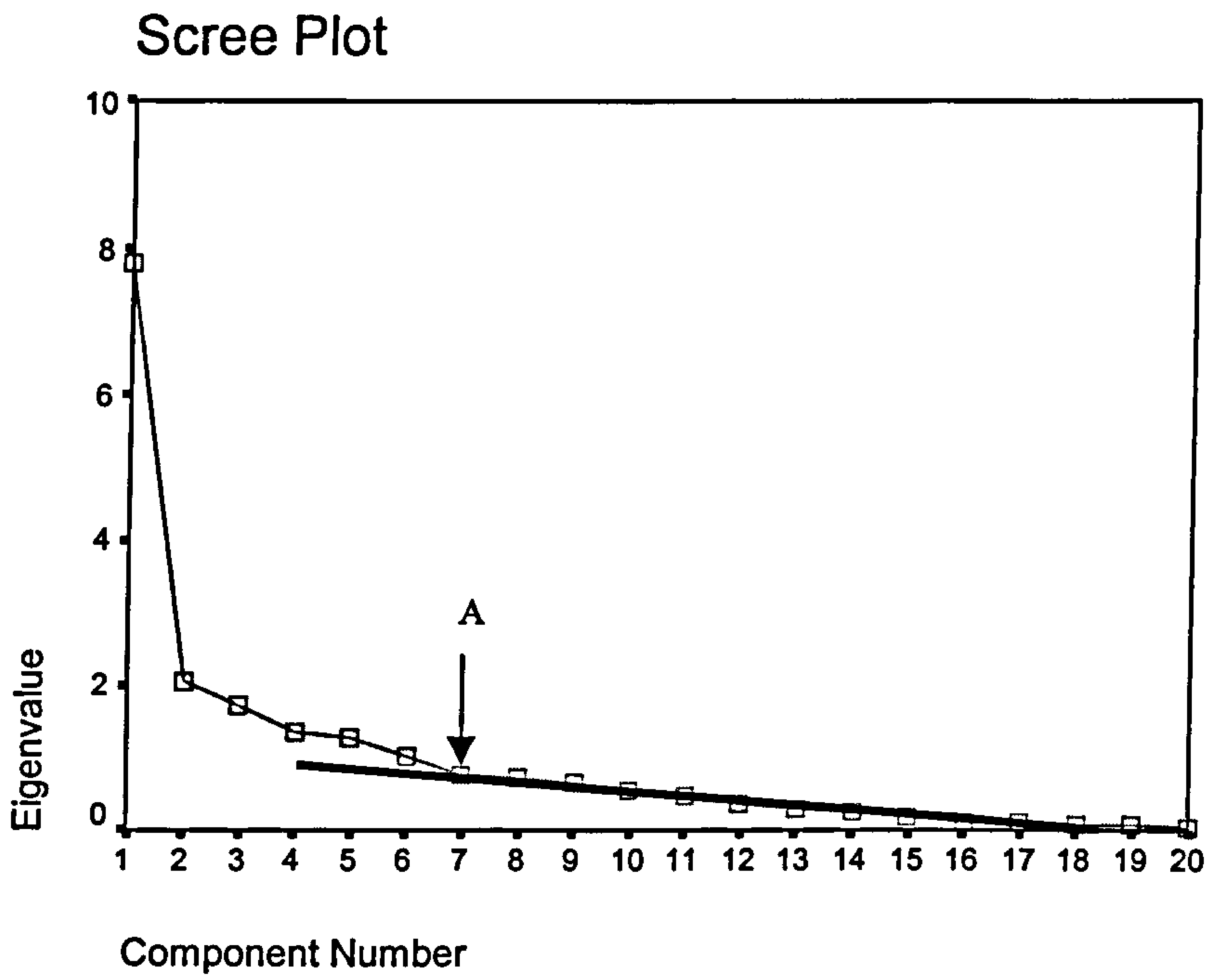

Figure G6.2 Scree plot of components' eigen values based on the PCA of contractor performance attributes

Table G6.4 Component correlation matrix based on the PCA of contractor performance attributes

Component	1	2	3	4	5	6
1	1.000	0.429	0.439	0.523	0.426	0.094
2		1.000	0.177	0.444	0.423	0.081
3			1.000	0.391	0.178	0.068
4				1.000	0.296	0.200
5					1.000	0.081
6						1.000

Table G6.5 Structure matrix of PCA of contractor performance attributes

Attributes	Component					
	1	2	3	4	5	6
COEVAAR						0.881
COWL					**0.808**	
COATTFI	0.578	0.526			**0.815**	
COATTTY	0.640					
COATTSI	0.744					
COATTRE	0.681	0.605				
COATTPP	**0.852**			0.514		
COATTSC	**0.784**		0.537	0.762		
COATTBU	**0.850**		0.668	0.600		
COATTQU	**0.778**			0.513		
COATTLI			**0.959**			
COATTIM			**0.925**			
COATTDI	0.591		0.633			
COATTSP	0.735			0.658		
COATTHS		0.634		0.621	0.582	
COATTTR		0.571		0.784		
COATTQC		0.629		0.748		
COATTSU		**0.943**				
COATTLA		**0.933**				
COATTWR				0.722		

Note: KMO = 0.776
Chi-square = 745.113 (degree of freedom = 190; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed

Appendix H:

Principal Components Analysis (PCA) of Performance Criteria

Appendix H1: Principal components analysis of client performance criteria based on architects' assessment

Appendix H2: Principal components analysis of client performance criteria based on contractors' assessment

Appendix H3: Principal components analysis of architect performance criteria based on clients' assessment

Appendix H4: Principal components analysis of architect performance criteria based on contractors' assessment

Appendix H5: Principal components analysis of contractor performance criteria based on clients' assessment

Appendix H6: Principal components analysis of contractor performance criteria based on architects' assessment

Table H1.1 Eigen values, percentage and total variance explained of PCA of client performance criteria

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	19.861	60.184	60.184
2	2.414	7.314	67.498
3	1.476	4.472	71.970
4	1.052	3.188	75.158
5	0.904	2.740	
6	0.844	2.557	
7	0.726	2.199	
8	0.714	2.164	
9	0.651	1.974	
10	0.588	1.783	

Note: Components 11-33 are not shown

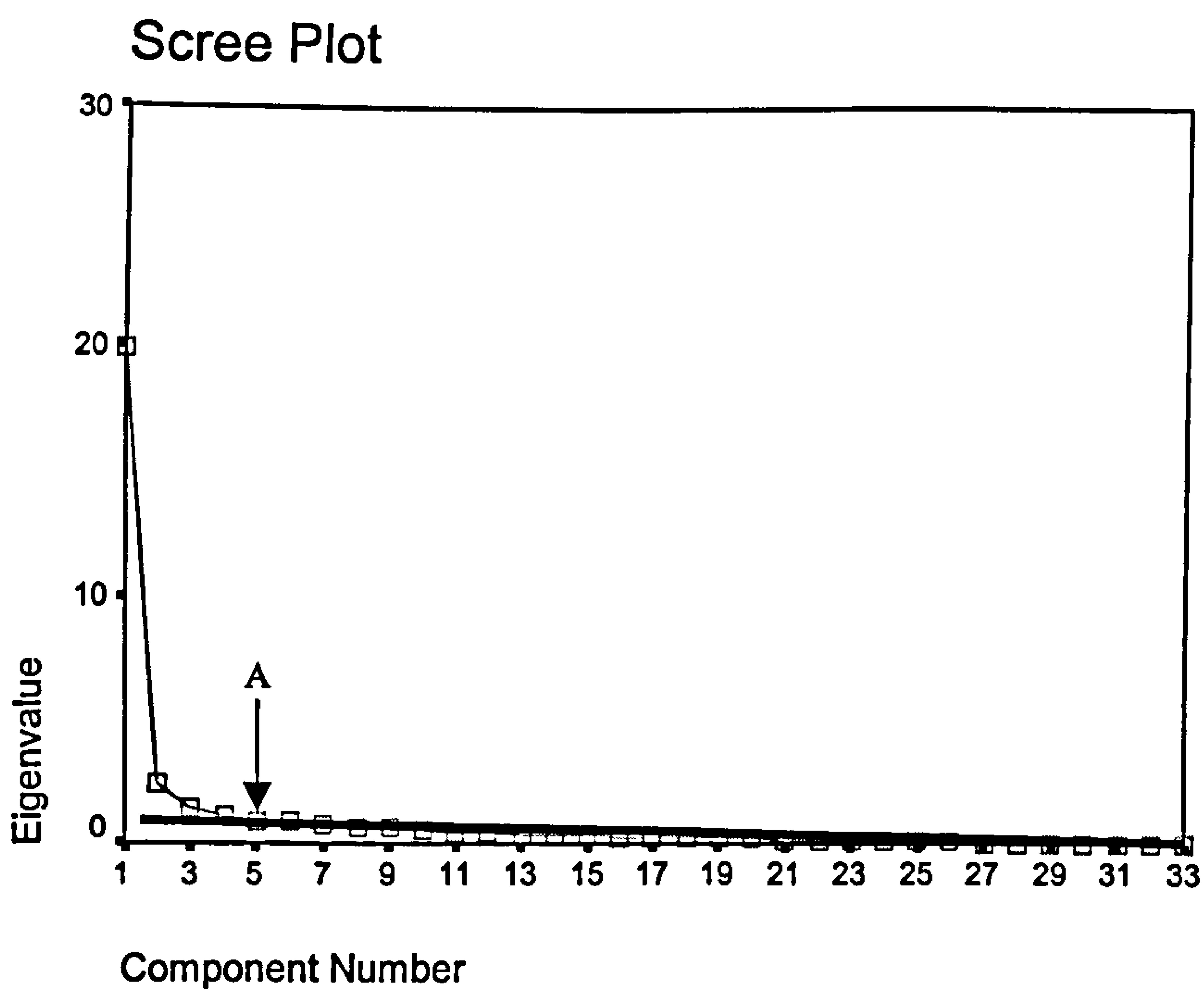

Figure H1.1 Scree plot of components' eigen values based on the PCA of client performance criteria

Table H1.2 Component correlation matrix based on the PCA of client performance criteria

Component	1	2	3	4
1	1.000	0.680	0.578	0.449
2		1.000	0.735	0.611
3			1.000	0.551
4				1.000

Table H1.3 Structure matrix of client performance criteria based on architects' assessment

Client Performance Criteria	Code	Satisfaction Measures			
		satis1	*satis2*	*satis3*	*satis4*
Understanding of Project Requirements					
· Quality of brief, in terms of clarity	U1		0.635		0.857
· Quality of brief, in terms of adequacy and appropriateness	U2	0.532	0.725	0.583	0.864
· Understanding of building process	U3			0.582	0.740
· Knowing what they want early	U4	0.544	0.594	0.554	0.879
· Clarity of thinking (not changing their mind)	U5	0.569	0.653	0.604	0.857
· Ability to convey what they want	U6		0.744	0.631	0.827
Finance					
· Adequacy of funding for the project	F1		0.528	0.759	
· Timeliness of payment	F2	0.639	0.690	0.695	
· Ease of financial approval due to variations	F3	0.695	0.656	0.676	
Decision Making					
· Ability to make rapid and decisive decisions	D1	0.725	0.865	0.663	0.595
· Quality of the decisions	D2	0.715	0.923	0.704	0.741
· Unity (i.e. clear and single voice)	D3	0.584	0.915	0.592	0.605
Management Skills					
· Delegation (give lead designer proper level of authority)	M1	0.599	0.732	0.525	
· Organisational skills	M2	0.601	0.893	0.741	0.632
· Performance in pre-planning (early stages performance)	M3		0.851	0.718	0.691
· Administration	M4		0.847	0.742	0.547
Support to Contractor / Architect					
· Information support (quality, timely, etc.)	S1	0.651	0.862	0.762	0.675
· Adequacy of time (achievable and realistic timescale)	S2		0.538	0.786	0.520
· Providing enough resources	S3		0.768	0.853	0.541
· Monitoring progress / performance	S4	0.575	0.746	0.885	0.655
· Adequate continuous involvement	S5	0.647	0.694	0.879	0.535
· Ability to balance between involvement and interference	S6	0.756	0.774	0.619	0.502
Attitude					
· Integrity and honesty	A1	0.760	0.701	0.644	
· Collaborative / spirit of cooperation / team work	A2	0.739	0.684	0.710	
· Commitment to project	A3	0.578	0.729	0.854	
· Responsiveness to problems (queries) that arise	A4	0.735	0.824	0.672	
· Understanding architect difficulties	A5	0.866	0.748	0.582	
· Attitude to variations caused by client changes	A6	0.770	0.797	0.591	
· Allowing architect to enjoy projects	A7	0.902	0.582		0.516
· Appreciation of architecture	A8	0.820			
· Ability to encourage attitude of pro-activeness of all	A9	0.794	0.632	0.665	
· Attitude towards advice (respect, open to solutions, etc.)	A10	0.911	0.752	0.614	
· Personality (e.g. general feeling on the pleasantness of the client)	A11	0.871	0.583		

Note: KMO = 0.850
Chi-square = 2062.929 (degree of freedom = 528; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed

Table H1.4 Correlation matrix of satisfaction measures derived from architects' assessment of client performance

		satis1	*satis2*	*satis3*	*satis4*	*avesat*	*totsat*	*repeat work*
satis1	r	1.000	*0.726*	*0.652*	*0.592*	*0.840*	**0.804**	**0.438**
	Sig. (1-tailed)		0.000	0.000	0.000	0.000	0.000	0.000
satis2	r		1.000	*0.809*	*0.780*	*0.939*	**0.815**	**0.531**
	Sig. (1-tailed)			0.000	0.000	0.000	0.000	0.000
satis3	r			1.000	*0.710*	*0.881*	**0.691**	**0.544**
	Sig. (1-tailed)				0.000	0.000	0.000	0.000
satis4	r				1.000	*0.878*	**0.705**	**0.369**
	Sig. (1-tailed)					0.000	0.000	0.000
avesat	r					1.000	**0.852**	**0.527**
	Sig. (1-tailed)						0.000	0.000
totsat	r						1.000	0.624
	Sig. (1-tailed)							0.000
repeat work	r							1.000
	Sig. (1-tailed)							
Average '*italic*' or '**bold**'		*0.781* (average of 10 correlation coefficients)					**0.773**	**0.482**

Note: r = Pearson correlation coefficient
N = number of samples = 54
The coefficient alpha = 0.9700 (for 24 criteria included to measure satisfaction)

Table H2.1 Eigen values, percentage and total variance explained of PCA of client performance criteria

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	**20.188**	**61.177**	**61.177**
2	**2.038**	**6.175**	**67.352**
3	**1.752**	**5.308**	**72.660**
4	**1.195**	**3.620**	**76.280**
5	**1.047**	**3.173**	**79.453**
6	0.901	2.729	
7	0.822	2.490	
8	0.743	2.250	
9	0.620	1.878	
10	0.521	1.579	

Note: Components 11-33 are not shown

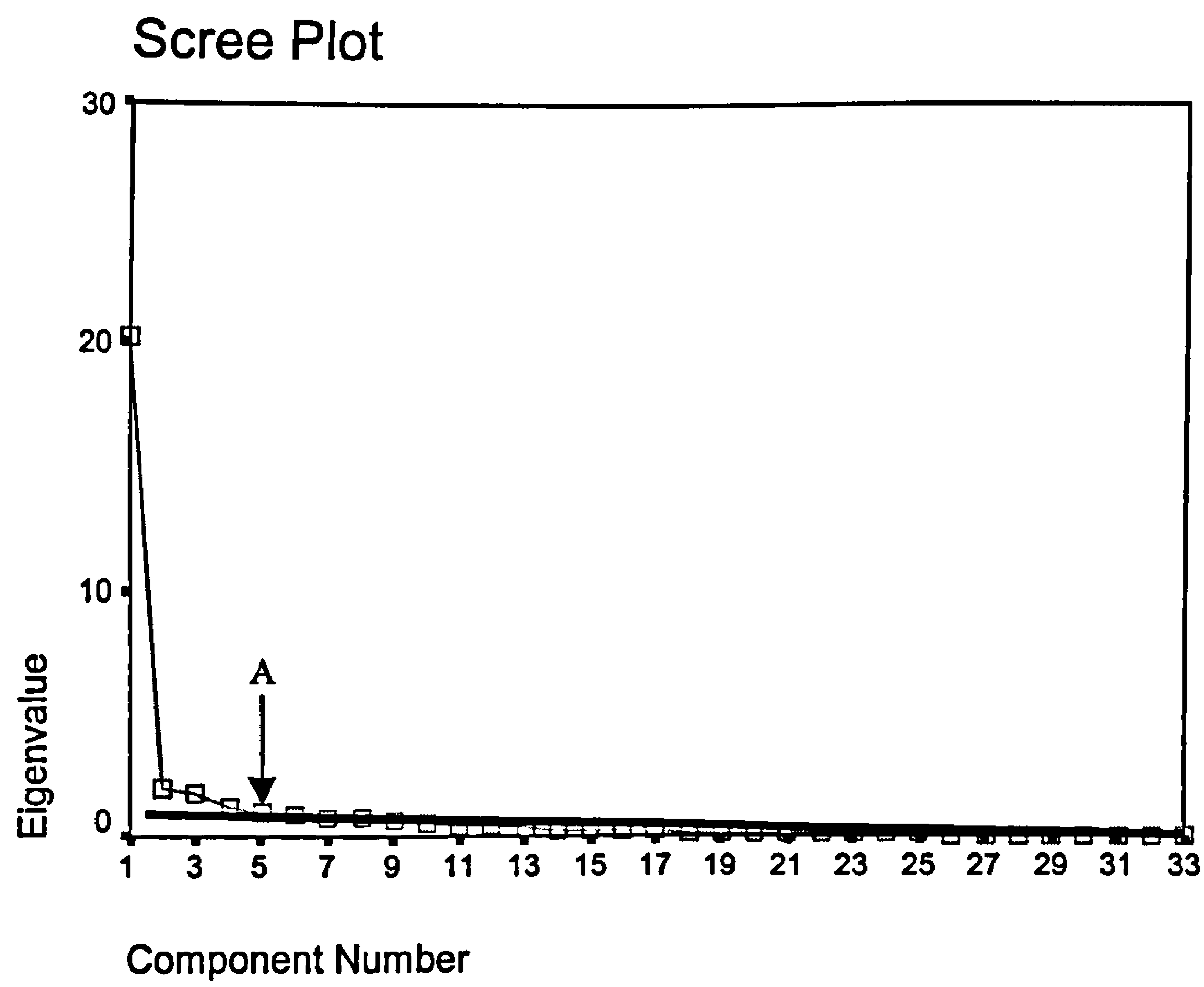

Figure H2.1 Scree plot of components' eigen values based on the PCA of client performance criteria

Table H2.2 Component correlation matrix based on the PCA of client performance criteria

Component	1	2	3	4	5
1	1.000	0.754	0.696	0.620	0.387
2		1.000	0.568	0.508	0.304
3			1.000	0.511	0.326
4				1.000	0.159
5					1.000

Table H2.3 Structure matrix of client performance criteria based on contractors' assessment

Client Performance Criteria	Code	Satisfaction Measures				
		satis1	*satis2*	*satis3*	*satis4*	*satis5*
Understanding of Project Requirements						
• Quality of brief, in terms of clarity	U1	0.649	0.571	0.596	0.828	
• Quality of brief, in terms of adequacy and appropriateness	U2	0.671	0.594	0.565	0.903	
• Understanding of building process	U3	0.546		0.521	0.796	
• Knowing what they want early	U4	0.567		0.813	0.647	
• Clarity of thinking (not changing their mind)	U5	0.639	0.557	0.873	0.663	
• Ability to convey what they want	U6	0.651	0.523	0.818	0.648	
Finance						
• Adequacy of funding for the project	F1					0.911
• Timeliness of payment	F2					0.932
• Ease of financial approval due to variations	F3	0.698	0.612			0.707
Decision Making						
• Ability to make rapid and decisive decisions	D1	0.792	0.604	0.759	0.506	
• Quality of the decisions	D2	0.818	0.685	0.841	0.570	
• Unity (i.e. clear and single voice)	D3	0.786	0.653	0.859		
Management Skills						
• Delegation (give lead designer proper level of authority)	M1	0.549	0.542	0.798		
• Organisational skills	M2	0.859	0.670	0.810	0.516	
• Performance in pre-planning (early stages performance)	M3	0.846	0.594	0.778	0.626	
• Administration	M4	0.854	0.678	0.625		
Support to Contractor / Architect						
• Information support (quality, timely, etc.)	S1	0.926	0.730	0.751	0.625	
• Adequacy of time (achievable and realistic timescale)	S2	0.867	0.602	0.660		
• Providing enough resources	S3	0.896	0.579	0.586	0.509	0.555
• Monitoring progress / performance	S4	0.827	0.674		0.692	
• Adequate continuous involvement	S5	0.836	0.805	0.541	0.754	
• Ability to balance between involvement and interference	S6	0.811	0.740	0.659	0.668	
Attitude						
• Integrity and honesty	A1	0.667	0.855		0.519	
• Collaborative / spirit of cooperation / team work	A2	0.693	0.889	0.636		
• Commitment to project	A3	0.604	0.908			
• Responsiveness to problems (queries) that arise	A4	0.882	0.811	0.603	0.617	
• Understanding contractor difficulties	A5	0.808	0.647	0.557	0.620	
• Attitude to variations caused by client changes	A6	0.882	0.718	0.616	0.686	
• Allowing contractor to enjoy projects	A7	0.807	0.605	0.560		
• Appreciation of architecture	A8	0.724	0.583	0.577	0.592	
• Ability to encourage attitude of pro-activeness of all	A9	0.830	0.825	0.701	0.577	
• Attitude towards advice (respect, open to solutions, etc.)	A10	0.783	0.829	0.509	0.576	
• Personality (e.g. general feeling on the pleasantness of the client)	A11	0.735	0.919	0.634	0.513	

Note: KMO = 0.863
Chi-square = 2291.618 (degree of freedom = 528; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed

Table H2.4 Correlation matrix of satisfaction measures derived from contractors' assessment of client performance

		satis1	*satis2*	*satis3*	*satis4*	*satis5*	*avesat*	*totsat*	*repeat work*
satis1	r	1.000	*0.761*	*0.740*	*0.714*	*0.437*	*0.909*	**0.835**	**0.441**
	Sig. (1-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000
satis2	r		1.000	*0.626*	*0.564*	*0.343*	*0.818*	**0.902**	**0.638**
	Sig. (1-tailed)			0.000	0.000	0.005	0.000	0.000	0.000
satis3	r			1.000	*0.702*	*0.349*	*0.851*	**0.739**	**0.385**
	Sig. (1-tailed)				0.000	0.005	0.000	0.000	0.002
satis4	r				1.000	*0.401*	*0.836*	**0.663**	**0.355**
	Sig. (1-tailed)					0.001	0.000	0.000	0.004
satis5	r					1.000	*0.620*	**0.376**	**0.312**
	Sig. (1-tailed)						0.000	0.002	0.010
avesat	r						1.000	**0.873**	**0.529**
	Sig. (1-tailed)							0.000	0.000
totsat	r							1.000	0.617
	Sig. (1-tailed)								0.000
repeat work	r								1.000
	Sig. (1-tailed)								
Average '*italic*' or '**bold**'			*0.645* (average of 15 correlation coefficients)					**0.731**	**0.443**

Note: r = Pearson correlation coefficient
N = number of samples = 55
The coefficient alpha = 0.9628 (for 22 criteria included to measure satisfaction)

Table H3.1 Eigen values, percentage and total variance explained of PCA of architect performance criteria

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	25.286	56.192	56.192
2	4.052	9.003	65.195
3	1.912	4.249	69.444
4	1.783	3.963	73.406
5	1.486	3.302	76.708
6	1.319	2.932	79.640
7	1.172	2.604	82.245
8	0.949	2.108	
9	0.883	1.962	
10	0.738	1.641	

Note: Components 11-45 are not shown

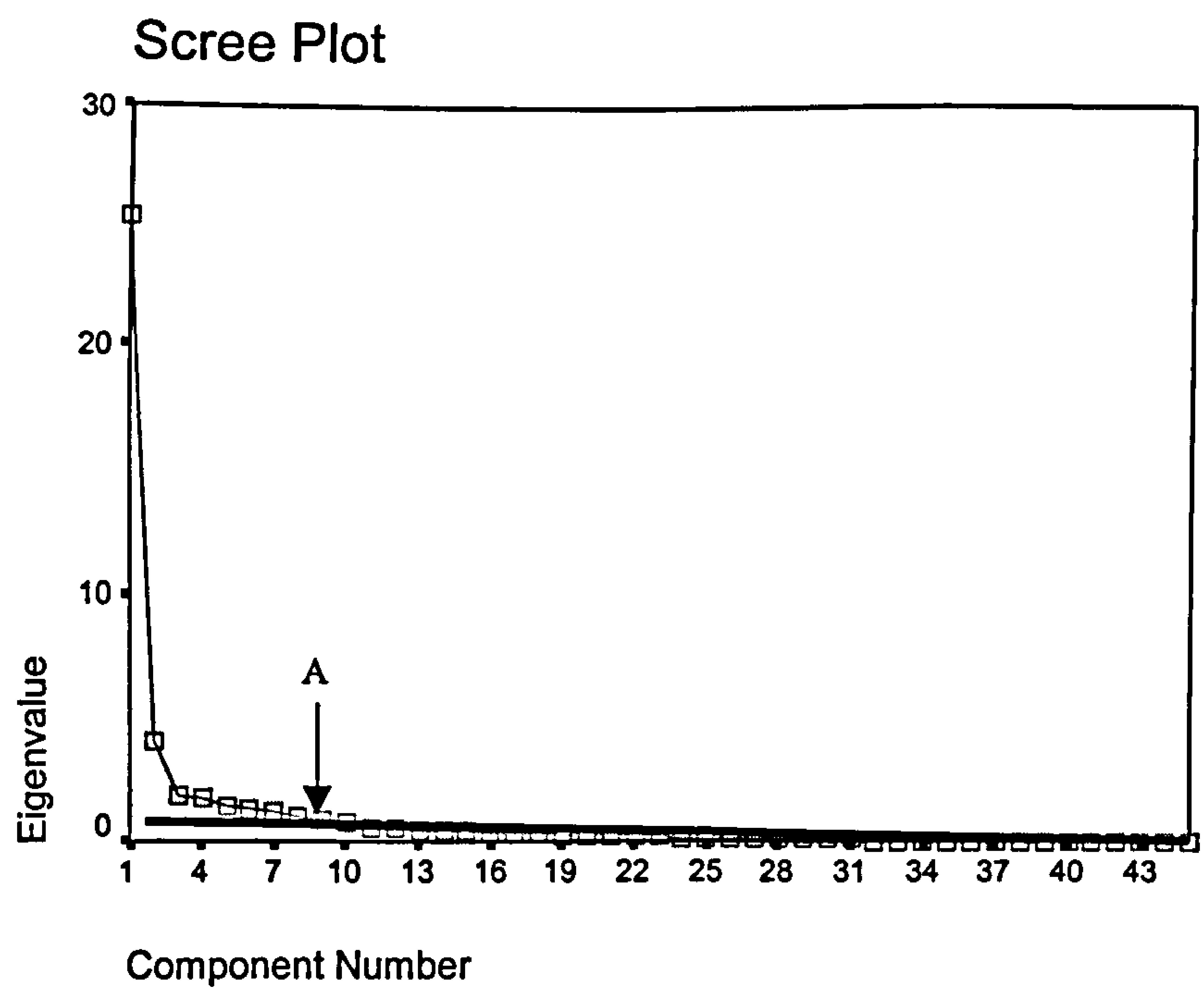

Figure H3.1 Scree plot of components' eigen values based on the PCA of architect performance criteria

Table H3.2 Component correlation matrix based on the PCA of architect performance criteria

Component	1	2	3	4	5	6	7
1	1.000	0.393	0.602	0.633	0.391	0.386	-0.048
2		1.000	0.231	0.312	0.485	0.331	0.011
3			1.000	0.469	0.286	0.290	0.045
4				1.000	0.266	0.243	-0.113
5					1.000	0.467	0.090
6						1.000	0.055
7							1.000

Table H3.3 Structure matrix of architect performance criteria based on clients' assessment

Architect Performance Criteria	Code	Satisfaction Measures						
		satis1	*satis2*	*satis3*	*satis4*	*satis5*	satis6	satis7
Pre-construction Stage								
~ First interview and design presentation (visibility)	P1					0.676	0.774	
~ Ability to develop brief and resolution of the brief	P2					0.807		
~ Method statement (ability to explain how the project will be handled)	P3		0.738			0.748		
~ Understanding of client culture (e.g. nature of client company) to assess the real need	P4		0.771					
Quality of Design								
~ Design suitability to solution (relevancy, practicallity)	D1		0.866			0.583		
~ Design buildability / constructability	D2	0.799		0.875	0.525			
~ Design flair or aesthetic sense and innovation	D3		0.782					
~ Design to provide value for money	D4	0.665		0.780	0.674			
~ Design to incorporate health and safety issues	D5			0.841				
~ Design concern for environmental issues	D6		0.822					
~ Design simplicity for operations and maintenance	D7	0.695		0.923				
~ Design adaptability or sustainability	D8	0.602		0.629		0.812	0.535	
~ Quality of detail drawing and specifications (e.g. accuracy, completeness)	D9	0.867		0.711				
Management Skill								
~ Design management and supervision	M1	0.899		0.549	0.643	0.521		
~ Ability to manage the construction process (as contract administrator)	M2	0.877		0.582	0.678			
~ Coordination between team members or consultants	M3	0.826			0.723			
~ Company organisational skills & org. structure	M4	0.707			0.562	0.526		
~ Management of resources (commitment of resources)	M5	0.941		0.517	0.554			
Technical Skill								
~ Practical construction knowledge	T1	0.869		0.545	0.674			
~ Suitability and quality of major building components or products selected	T2	0.514	0.799			0.580		
~ Incorporation of mechanical and electrical services into the structure	T3	0.830		0.584	0.527		0.508	
~ Understanding and compliance with legislation and statutory requirements (CDM, fire regl., etc.)	T4	0.664	0.697		0.566	0.632		
Quality of Services								
~ Effective handling of complaints	Q1	0.818					0.592	
~ Telephone inquiries and correspondence handled courteously and adequately	Q2	0.663		0.623		0.522	0.676	
~ Speed and reliability of service (e.g. redrawing)	Q3	0.857	0.501		0.571			
~ Responsiveness to client queries (flexibility)	Q4	0.863	0.580		0.581			
~ Ability to make rapid and decisive decisions	Q5	0.897		0.629	0.582			
~ Commitment of key persons (active & continuous)	Q6	0.893		0.651	0.594			
~ Willingness to draft the documents / drawings, not only do conceptual work	Q7	0.715		0.544	0.882			
~ Follow up (e.g. defects) or services offered after project completion	Q8	0.892		0.541	0.543			
~ Corporate hospitality	Q9						0.814	
Attitude								
~ Integrity	A1	0.792			0.676			
~ Collaborative / spirit of cooperation / team work	A2	0.900		0.552	0.646			
~ Keep the client informed (willingness to involve cl.)	A3	0.921		0.624	0.514			
~ Communication with other coalition members	A4	0.887						
~ Commercial attitude (e.g. additional fees)	A5	0.534			0.723			
~ Pro-active to know site problems (e.g. by regular site visit)	A6	0.697			0.616			
~ Attitude in dealing with client and contractor	A7	0.894		0.613	0.549			
~ Avoidance of design changes	A8	0.750		0.700	0.561			
~ Listen to what client wants (customer focus)	A9	0.657		0.607	0.622			
~ Responsibility for their decision (understand the cost of their recommendations)	A10	0.808		0.675	0.699			
Main Criteria								
~ General quality of building (both functionality and aesthetics)	C1	0.500	0.606		0.751			
~ Compliance with information required schedule	C2	0.830		0.777	0.649			
~ Compliance with requirements	C3	0.732		0.635	0.801			
~ Compliance to budget	C4	0.840		0.628	0.774			

Note: KMO = 0.654
Chi-square = 2941.087 (degree of freedom = 990; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed
Satis6 and satis7 were not used (for reason, refer to section 8.4.1.1, p.196)

Table H3.4 Correlation matrix of satisfaction measures derived from clients' assessment of architect performance

		satis1	*satis2*	*satis3*	*satis4*	*satis5*	*avesat*	*totsat*	*repeat work*
satis1	r	1.000	*0.532*	*0.698*	*0.724*	*0.551*	*0.871*	**0.862**	**0.625**
	Sig. (1-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000
satis2	r		1.000	*0.574*	*0.514*	*0.559*	*0.755*	**0.492**	**0.425**
	Sig. (1-tailed)			0.000	0.000	0.000	0.000	0.000	0.001
satis3	r			1.000	*0.606*	*0.633*	*0.872*	**0.687**	**0.537**
	Sig. (1-tailed)				0.000	0.000	0.000	0.000	0.000
satis4	r				1.000	*0.453*	*0.802*	**0.744**	**0.738**
	Sig. (1-tailed)					0.001	0.000	0.000	0.000
satis5	r					1.000	*0.781*	**0.558**	**0.537**
	Sig. (1-tailed)						0.000	0.000	0.000
avesat	r						1.000	**0.826**	**0.695**
	Sig. (1-tailed)							0.000	0.000
totsat	r							1.000	0.649
	Sig. (1-tailed)								0.000
repeat work	r								1.000
	Sig. (1-tailed)								
Average '*italic*' or '**bold**'			*0.662* (average of 15 correlation coefficients)					**0.695**	**0.593**

Note: r = Pearson correlation coefficient
N = number of samples = 48
The coefficient alpha = 0.9769 (for 33 criteria included to measure satisfaction)

Table H4.1 Eigen values, percentage and total variance explained of PCA of architect performance criteria

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	25.246	56.102	56.102
2	2.506	5.568	61.670
3	2.428	5.395	67.065
4	2.205	4.899	71.964
5	1.497	3.327	75.292
6	1.351	3.003	78.295
7	1.243	2.761	81.056
8	0.928	2.063	
9	0.821	1.825	
10	0.704	1.564	

Note: Components 11-45 are not shown

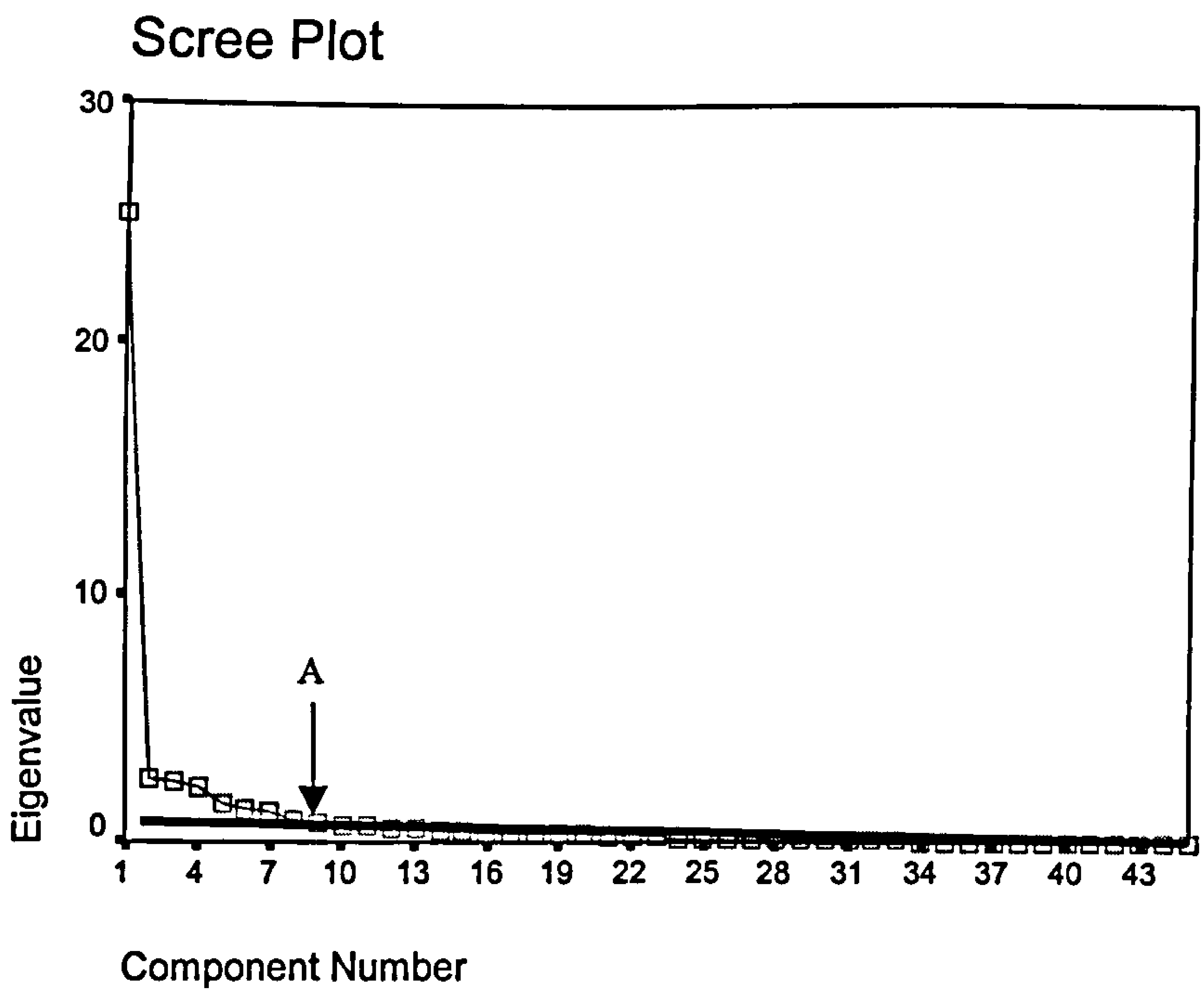

Figure H4.1 Scree plot of components' eigen values based on the PCA of architect performance criteria

Table H4.2 Component correlation matrix based on the PCA of architect performance criteria

Component	1	2	3	4	5	6	7
1	1.000	0.666	0.592	0.644	0.485	0.462	-0.102
2		1.000	0.616	0.675	0.572	0.348	-0.136
3			1.000	0.556	0.486	0.405	-0.186
4				1.000	0.461	0.367	-0.048
5					1.000	0.076	-0.214
6						1.000	-0.024
7							1.000

Table H4.3 Structure matrix of architect performance criteria based on contractors' assessment

Architect Performance Criteria	Code	Performance Measures						
		satis1	*satis2*	*satis3*	*satis4*	*satis5*	satis6	satis7
Pre-construction Stage								
~ First interview and design presentation (visibility)	P1			0.831				
~ Ability to develop brief and resolution of the brief	P2	0.635	0.542	0.846	0.515			
~ Method statement (ability to explain how the project will be handled)	P3	0.501	0.568	0.881	0.517			
~ Understanding of client culture (e.g. nature of client company) to assess the real need	P4	0.559	0.522	0.876		0.527		
Quality of Design								
~ Design suitability to solution (relevancy, practicallity)	D1	0.728	0.536	0.712	0.645		0.680	
~ Design buildability / constructability	D2	0.754	0.792	0.548	0.860	0.505		
~ Design flair or aesthetic sense and innovation	D3							0.822
~ Design to provide value for money	D4		0.599	0.547	0.868	0.557		
~ Design to incorporate health and safety issues	D5	0.543	0.639		0.791	0.530		
~ Design concern for environmental issues	D6				0.783			
~ Design simplicity for operations and maintenance	D7	0.634	0.658	0.629	0.865		0.549	
~ Design adaptability or sustainability	D8	0.697	0.621	0.510	0.846		0.564	
~ Quality of detail drawing and specifications (e.g. accuracy, completeness)	D9	0.677	0.820	0.681	0.564		0.595	
Management Skill								
~ Design management and supervision	M1	0.786	0.796	0.647	0.818			
~ Ability to manage the construction process (as contract administrator)	M2	0.659	0.833	0.608	0.715	0.618		
~ Coordination between team members or consultants	M3	0.775	0.838	0.734	0.749			
~ Company organisational skills & org. structure	M4	0.822	0.807	0.607	0.756			
~ Management of resources (commitment of resources)	M5	0.822	0.772	0.660	0.674	0.673		
Technical Skill								
~ Practical construction knowledge	T1		0.651	0.693		0.743		
~ Suitability and quality of major building components or products selected	T2	0.569	0.611	0.719	0.642	0.790		
~ Incorporation of mechanical and electrical services into the structure	T3	0.780	0.596	0.683	0.790		0.545	
~ Understanding and compliance with legislation and statutory requirements (CDM, fire regl., etc.)	T4	0.686		0.602	0.564		0.783	
Quality of Services								
~ Effective handling of complaints	Q1	0.855	0.723	0.565	0.686	0.574		
~ Telephone inquiries and correspondence handled courteously and adequately	Q2	0.807	0.523		0.640	0.625		
~ Speed and reliability of service (e.g. redrawing)	Q3	0.790	0.797	0.662	0.645	0.737		
~ Responsiveness to queries (flexibility)	Q4	0.618	0.620	0.505		0.839		
~ Ability to make rapid and decisive decisions	Q5	0.871	0.702		0.556	0.520		
~ Commitment of key persons (active & continuous)	Q6	0.869						
~ Willingness to draft the documents / drawings, not only do conceptual work	Q7	0.829	0.641	0.552	0.533	0.618		
~ Follow up (e.g. defects) or services offered after project completion	Q8					0.682		
~ Corporate hospitality	Q9						0.707	
Attitude								
~ Integrity	A1	0.610	0.742	0.666		0.729		
~ Collaborative / spirit of cooperation / team work	A2	0.818	0.756	0.620	0.629	0.615		
~ Keep the client informed (willingness to involve cl.)	A3	0.822					0.607	
~ Communication with other coalition members	A4	0.880	0.787	0.615	0.684			
~ Commercial attitude (e.g. additional fees)	A5	0.527	0.636	0.647	0.624		0.625	
~ Pro-active to know site problems (e.g. by regular site visit)	A6	0.753	0.592	0.595		0.723		
~ Attitude in dealing with client and contractor	A7	0.833	0.741	0.708	0.698	0.650		
~ Avoidance of design changes	A8	0.625	0.846	0.543	0.606	0.515	0.572	
~ Listen to what client wants (customer focus)	A9	0.792					0.691	
~ Responsibility for their decision (understand the cost of their recommendations)	A10	0.661	0.798	0.631	0.646	0.543	0.608	
Main Criteria								
~ General quality of building (both functionality and aesthetics)	C1				0.526			0.521
~ Compliance with information required schedule	C2	0.590	0.908	0.541	0.694	0.665		
~ Compliance with requirements	C3	0.600	0.851		0.567			
~ Compliance to budget	C4	0.545	0.867	0.567	0.623			

Note: KMO = 0.688
Chi-square = 2182.716 (degree of freedom = 990; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed
Satis6 and satis7 were not used (for reason, refer to section 8.4.1.1, p.196)

Table H4.4 Correlation matrix of satisfaction measures derived from contractors' assessment of architect performance

		satis1	*satis2*	*satis3*	*satis4*	*satis5*	*avesat*	*totsat*	*repeat work*
satis1	r	1.000	*0.776*	*0.603*	*0.660*	*0.680*	*0.888*	**0.847**	**0.614**
	Sig. (1-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000
satis2	r		1.000	*0.684*	*0.771*	*0.614*	*0.928*	**0.866**	**0.591**
	Sig. (1-tailed)			0.000	0.000	0.000	0.000	0.000	0.000
satis3	r			1.000	*0.560*	*0.352*	*0.769*	**0.718**	**0.528**
	Sig. (1-tailed)				0.000	0.004	0.000	0.000	0.000
satis4	r				1.000	*0.496*	*0.832*	**0.718**	**0.479**
	Sig. (1-tailed)					0.000	0.000	0.000	0.000
satis5	r					1.000	*0.751*	**0.660**	**0.549**
	Sig. (1-tailed)						0.000	0.000	0.000
avesat	r						1.000	**0.914**	**0.666**
	Sig. (1-tailed)							0.000	0.000
totsat	r							1.000	0.688
	Sig. (1-tailed)								0.000
repeat work	r								1.000
	Sig. (1-tailed)								
Average '*italic*' or 'bold'			***0.691*** (average of 15 correlation coefficients)					**0.787**	**0.571**

Note: r = Pearson correlation coefficient
N = number of samples = 55
The coefficient alpha = 0.9685 (for 26 criteria included to measure satisfaction)

Table H5.1 Eigen values, percentage and total variance explained of PCA of contractor performance criteria

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	28.873	60.151	60.151
2	2.852	5.941	66.092
3	2.067	4.306	70.399
4	1.374	2.862	73.260
5	1.239	2.581	75.841
6	1.172	2.443	78.284
7	1.032	2.150	80.434
8	0.914	1.904	
9	0.836	1.742	
10	0.772	1.609	

Note: Components 11-48 are not shown

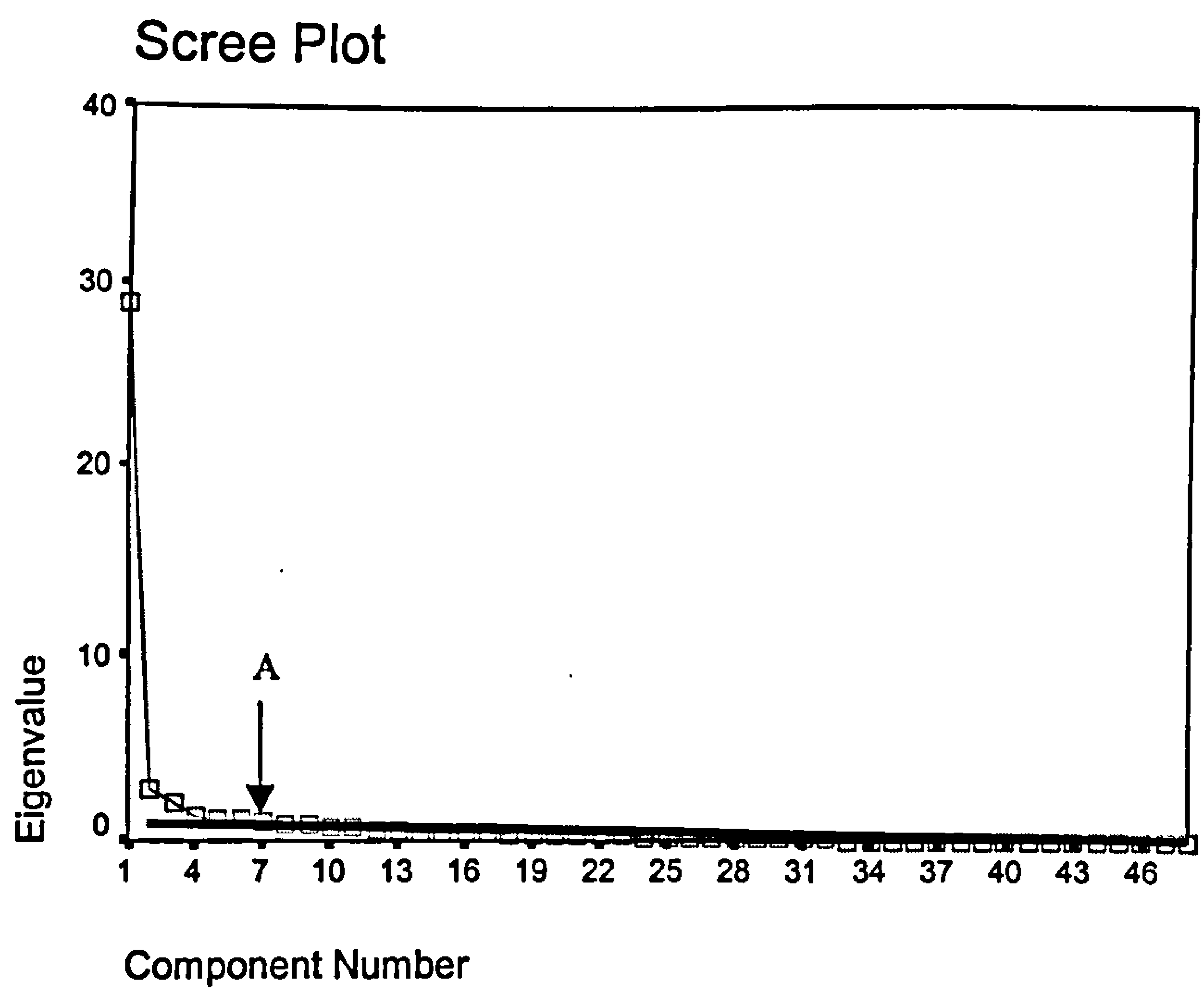

Figure H5.1 Scree plot of components' eigen values based on the PCA of contractor performance criteria

Table H5.2 Component correlation matrix based on the PCA of contractor performance criteria

Component	1	2	3	4	5	6	7
1	1.000	0.694	0.525	0.625	0.612	0.144	0.196
2		1.000	0.553	0.625	0.562	-0.056	0.172
3			1.000	0.515	0.594	-0.045	0.147
4				1.000	0.546	0.076	0.226
5					1.000	0.073	0.211
6						1.000	0.257
7							1.000

Table H5.3 Structure matrix of contractor performance criteria based on clients' assessment

Contractor Performance Criteria	Code	Satisfaction measures						
		satis1	*satis2*	*satis3*	*satis4*	*satis5*	satis6	satis7
Pre-construction Stage								
~ First interview and presentation	P1			$\boxed{0.759}$		0.561		
~ Ability and willingness to help develop brief	P2		0.537	$\boxed{0.839}$				
~ Contribution to design and buildability of project	P3	0.559		$\boxed{0.727}$	0.500	0.525		
~ Plan of work and method statement	P4		0.564	$\boxed{0.900}$	0.583	0.604		
~ Understanding of contract and specifications	P5	0.604	0.558	$\boxed{0.779}$		0.566		
Construction Stage								
Site management								
~ Site supervision and control	S1	0.542	0.733	0.653	0.774	0.673		
~ Site organisation, tidiness and cleanliness	S2	0.685	0.730	0.643	0.731	0.758		
~ Ability to plan and programme properly	S3	0.580	0.655	0.705	0.744	0.573		
~ Health and safety performance / management	S4	0.729	0.764	0.769	0.675	0.761		
~ Compliance to regulations (CDM, etc.)	S5	0.692	0.743	0.792	0.610	0.779		
Resource management								
~ Material management	R1	0.615	0.625	0.608	0.539	$\boxed{0.908}$		
~ Man power management (sufficient quantity and quality of craftsmen)	R2	0.685	0.796	0.696	0.580	0.785		
~ Equipment and plant management	R3	0.663	0.594	0.728	0.506	$\boxed{0.835}$		
~ Management and co-ordination of subcontractors and suppliers	R4	0.689	0.654	0.749	0.660	0.817		
~ Payment to subcontractors and suppliers (on time)	R5	0.775		0.687	0.519	0.603		
~ Strength of contractor site team (i.e. quantity)	R6	0.604	0.690	0.767	0.644	0.557		
~ Concern/awareness of environmental issues	R7			0.659		$\boxed{0.824}$		
Site personnel								
~ Cooperation with client (i.e. client representative)	E1	0.725	0.633	0.670	$\boxed{0.893}$	0.609		
~ Individual performance and ability	E2	0.689	0.704	0.657	$\boxed{0.849}$	0.614		
~ Project manager performance and adequacy of authority	E3	0.621	0.660	0.578	$\boxed{0.870}$	0.687		
~ Site manner (i.e. no loud noises and swearing)	E4	0.517			0.661	$\boxed{0.778}$		
Variations and drawings								
~ Processing variations (e.g. speed, flexibility)	V1	0.630	0.631		0.648	0.508		
~ Preparation of shop drawings and as-built drawings	V2	0.738	0.513		0.612	0.687		
~ Contribution to development of design drawings	V3	0.529					0.752	
Completion Stage & Ease of Delivery								
~ Completion of defects	C1	0.665	$\boxed{0.794}$	0.516	0.556	0.684		
~ Smoothness of operation and hand-over	C2	0.781	0.769	0.567	0.509	0.704		
~ Quality of hand-over document (O&M manual, H&S)	C3	$\boxed{0.827}$	0.687	0.583	0.515	0.663		
~ Ease / speed of settlement of final account	C4	0.662	$\boxed{0.804}$	0.502				
~ Ease of delivery (general feeling on how things went)	C5	0.741	$\boxed{0.922}$		0.641	0.515		
Principal								
~ Adherence to schedule (time performance)	M1	0.566	$\boxed{0.808}$	0.652	0.649			
~ Adherence to budget (cost performance)	M2	0.661	$\boxed{0.898}$	0.521	0.627	0.558		
~ Quality of construction and workmanship	M3	0.738	$\boxed{0.861}$	0.554	0.638	0.604		
Quality of Service								
~ Handling of complaints (effectiveness)	Q1	0.582	0.755		0.674	0.645		
~ Telephone inquiries and correspondence handled courteously and adequately	Q2	$\boxed{0.864}$	0.619		0.599	0.601		
~ Speed and reliability of service	Q3	$\boxed{0.833}$	0.704	0.602	0.716	0.554		
~ Responsiveness to client's queries	Q4	0.799	0.678	0.514	0.764			
~ Ability to make rapid decisions	Q5	$\boxed{0.862}$	0.627		0.567	0.551		
~ Commitment of key person (active & continuous)	Q6	0.726	0.606	0.538	0.748	0.625		
~ Corporate hospitality	Q7							0.830
~ Administration	Q8	$\boxed{0.871}$	0.648		0.527	0.630		
Attitude								
~ Honesty and integrity	A1	0.830	0.813	0.517	0.708	0.519		
~ Collaborative / spirit of cooperation / team work	A2	0.723	0.735	0.536	$\boxed{0.841}$			
~ Customer focus / proactive to understand client	A3	0.814	0.733		0.748	0.646		
~ Keep the client informed	A4	$\boxed{0.930}$	0.679		0.685	0.625		
~ Communication (to coalition member & site person)	A5	$\boxed{0.903}$	0.664	0.540	0.650			
~ Pro-active attitude toward problems	A6	0.705	0.611		$\boxed{0.844}$			
~ Avoidance of claims (i.e. not claims conscious)	A7	0.509	0.733		0.654			
~ Responsibility for their decision (understand the cost of their recommendations)	A8	$\boxed{0.764}$	0.640		0.640	0.553		

Note: KMO = 0.673
Chi-square = 3198.153 (degree of freedom = 1128; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed
Satis6 and satis7 were not used (for reason, refer to section 8.4.1.1, p.196)

Table H5.4 Correlation matrix of satisfaction measures derived from clients' assessment of contractor performance

		satis1	*satis2*	*satis3*	*satis4*	*satis5*	*avesat*	*totsat*	*repeat work*
satis1	r	1.000	*0.819*	*0.602*	*0.816*	*0.708*	*0.896*	**0.849**	**0.755**
	Sig. (1-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000
satis2	r		1.000	*0.658*	*0.790*	*0.636*	*0.894*	**0.858**	**0.650**
	Sig. (1-tailed)			0.000	0.000	0.000	0.000	0.000	0.000
satis3	r			1.000	*0.669*	*0.777*	*0.845*	**0.640**	**0.547**
	Sig. (1-tailed)				0.000	0.000	0.000	0.000	0.000
satis4	r				1.000	*0.664*	*0.893*	**0.879**	**0.701**
	Sig. (1-tailed)					0.000	0.000	0.000	0.000
satis5	r					1.000	*0.861*	**0.639**	**0.441**
	Sig. (1-tailed)						0.000	0.000	0.001
avesat	r						1.000	**0.881**	**0.704**
	Sig. (1-tailed)							0.000	0.000
totsat	r							1.000	0.788
	Sig. (1-tailed)								0.000
repeat work	r								1.000
	Sig. (1-tailed)								
Average '*italic*' or 'bold'			*0.769* (average of 15 correlation coefficients)					**0.791**	**0.633**

Note: r = Pearson correlation coefficient
N = number of samples = 50
The coefficient alpha = 0.9738 (for 28 criteria included to measure satisfaction)

Table H6.1 Eigen values, percentage and total variance explained of PCA of contractor performance criteria

Component	Eigen value	Variance explained	
		Percentage	Cumulative
1	30.775	64.114	64.114
2	2.318	4.830	68.943
3	1.948	4.059	73.002
4	1.388	2.891	75.894
5	1.305	2.718	78.612
6	1.152	2.400	81.011
7	0.998	2.079	
8	0.919	1.914	
9	0.816	1.700	
10	0.664	1.384	

Note: Components 11-48 are not shown

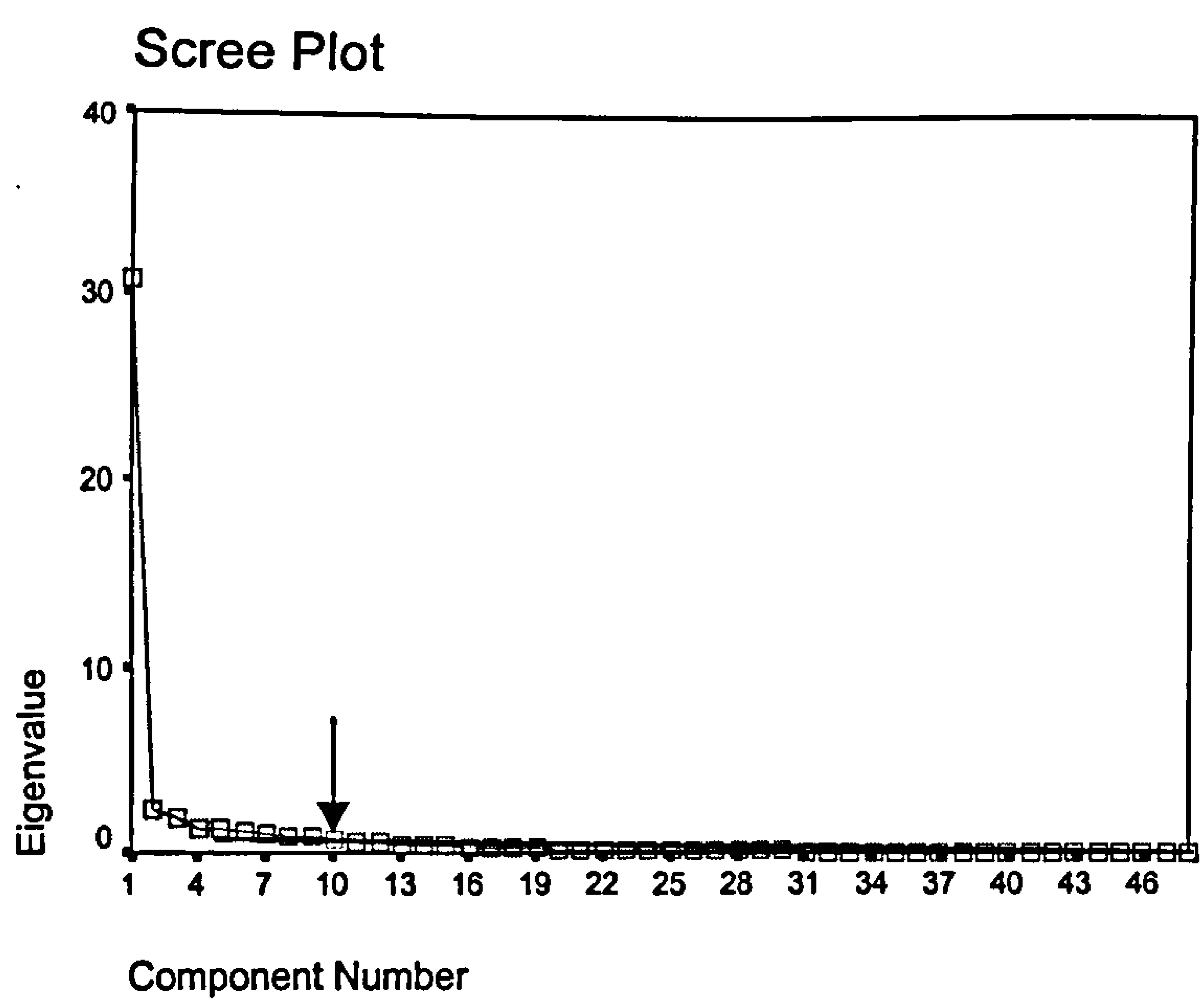

Figure H6.1 Scree plot of components' eigen values based on the PCA of contractor performance criteria

Table H6.2 Component correlation matrix based on the PCA of contractor performance criteria

Component	1	2	3	4	5	6
1	1.000	0.796	0.596	0.563	0.177	0.233
2		1.000	0.570	0.524	0.111	0.150
3			1.000	0.438	0.068	0.195
4				1.000	0.010	0.357
5					1.000	-0.311
6						1.000

Table H6.3 Structure matrix of contractor performance criteria based on architects' assessment

Contractor Performance Criteria	Code	Satisfaction Measures					
		satis1	*satis2*	*satis3*	*satis4*	*satis5*	*satis6*
Pre-construction Stage							
~ First interview and presentation	P1			0.621	0.552		
~ Ability and willingness to help develop brief	P2					0.811	
~ Contribution to design and buildability of project	P3				0.732	0.528	
~ Plan of work and method statement	P4	0.569			0.871		
~ Understanding of contract and specifications	P5	0.595	0.539	0.515	0.899		
Construction Stage							
Site management							
~ Site supervision and control	S1	0.716	0.844	0.652	0.610		
~ Site organisation, tidiness and cleanliness	S2	0.668	0.838	0.734	0.532		
~ Ability to plan and programme properly	S3	0.860	0.848	0.645	0.709		
~ Health and safety performance / management	S4	0.552	0.597	0.907			
~ Compliance to regulations (CDM, etc.)	S5	0.639	0.665	0.915			
Resource management							
~ Material management	R1	0.709	0.713	0.764	0.652		
~ Man power management (sufficient quantity and quality of craftsmen	R2	0.795	0.795	0.632	0.574		
~ Equipment and plant management	R3	0.676	0.768	0.686			
~ Management and co-ordination of subcontractors and suppliers	R4	0.795	0.818	0.664	0.690		
~ Payment to subcontractors and suppliers (on time)	R5	0.672	0.745				
~ Strength of contractor site team (i.e. quantity)	R6	0.799	0.769	0.648			
~ Concern/awareness for environmental issues	R7	0.721	0.552	0.759	0.503		
Site personnel							
~ Cooperation with client (i.e. client representative)	E1	0.661	0.853				
~ Individual performance and ability	E2	0.755	0.949	0.545			
~ Project manager performance and adequacy of authority	E3	0.779	0.892	0.506			
~ Site manner (i.e. no loud noises and swearing)	E4	0.558	0.775		0.502		
Variations and drawings							
~ Processing variations (e.g. speed, flexibility)	V1	0.729	0.800		0.658		
~ Preparation of shop drawings and as-built drawings	V2	0.833	0.636		0.557		
~ Contribution to development of design drawings	V3	0.778	0.527			0.556	
Completion Stage & Ease of Delivery							
~ Completion of defects	C1	0.829	0.651	0.637			
~ Smoothness of operation and hand-over	C2	0.901	0.708	0.619			
~ Quality of hand-over document (O&M manual, H&S)	C3	0.789	0.623	0.504			
~ Ease / speed of settlement of final account	C4	0.826	0.635		0.533		
~ Ease of delivery (general feeling on how things went)	C5	0.920	0.787	0.622	0.569		
Principal							
~ Adherence to schedule (time performance)	M1	0.934	0.763	0.620	0.591		
~ Adherence to budget (cost performance)	M2	0.928	0.804	0.647	0.626		
~ Quality of construction and workmanship	M3	0.861	0.835	0.676	0.692		
Quality of Service							
~ Handling of complaints (effectiveness)	Q1	0.769	0.776	0.687			
~ Telephone inquiries and correspondence handled courteously and adequately	Q2	0.830	0.906	0.553	0.528		
~ Speed and reliability of service	Q3	0.927	0.777	0.619	0.628		
~ Responsiveness to architects' queries	Q4	0.914	0.786		0.654		
~ Ability to make rapid decisions	Q5	0.895	0.738		0.531		
~ Commitment of key person (active & continuous)	Q6	0.816	0.778	0.514			
~ Corporate hospitality	Q7						0.724
~ Administration	Q8	0.851	0.680	0.586	0.593		
Attitude							
~ Honesty and integrity	A1	0.815	0.824	0.631	0.574		
~ Collaborative / spirit of cooperation / team work	A2	0.835	0.897	0.630	0.601		
~ Customer focus / proactive to understand architect	A3	0.886	0.851	0.517	0.582		
~ Keep the architect informed	A4	0.897	0.807	0.562	0.563		
~ Communication (to coalition member & site person)	A5	0.864	0.875	0.571	0.640		
~ Pro-active attitude toward problems	A6	0.888	0.822	0.513	0.512		
~ Avoidance of claims (i.e. not claims conscious)	A7	0.729	0.737		0.574		
~ Responsibility for their decision (understand the cost of his recommendation)	A8	0.882	0.726		0.551		

Note: Loadings less than 0.5 were suppressed
Chi-square = 2265.096 (degree of freedom = 1128; $p < 0.0005$)
Factor loadings less than 0.5 were suppressed
Satis6 and satis7 were not used (for reason, refer to section 8.4.1.1, p.196)

Table H6.4 Correlation matrix of satisfaction measures derived from architects' assessment of contractor performance

		satis1	*satis2*	*satis3*	*satis4*	*avesat*	*totsat*	*repeat work*
satis1	r	1.000	*0.800*	*0.623*	*0.670*	*0.915*	**0.887**	**0.832**
	Sig. (1-tailed)		0.000	0.000	0.000	0.000	0.000	0.000
satis2	r		1.000	*0.661*	*0.556*	*0.891*	**0.900**	**0.814**
	Sig. (1-tailed)			0.000	0.000	0.000	0.000	0.000
satis3	r			1.000	*0.475*	*0.810*	**0.635**	**0.573**
	Sig. (1-tailed)				0.000	0.000	0.000	0.000
satis4	r				1.000	*0.784*	**0.618**	**0.627**
	Sig. (1-tailed)					0.000	0.000	0.000
avesat	r					1.000	**0.898**	**0.841**
	Sig. (1-tailed)						0.000	0.000
totsat	r						1.000	0.873
	Sig. (1-tailed)							0.000
repeat work	r							1.000
	Sig. (1-tailed)							
Average '*italic*' or '**bold**'		*0.719* (average of 10 correlation coefficients)					**0.788**	**0.737**

Note: r = Pearson correlation coefficient
N = number of samples = 54
The coefficient alpha = 0.9774 (for 25 criteria included to measure satisfaction)

Appendix I:

Checking Regression Assumptions for MR Models

Appendix I1: Checking regression assumptions for MR model of architects' assessment of client performance

Appendix I2: Checking regression assumptions for MR model of contractors' assessment of client performance

Appendix I3: Checking regression assumptions for MR model of clients' assessment of architect performance

Appendix I4: Checking regression assumptions for MR model of contractors' assessment of architect performance

Appendix I5: Checking regression assumptions for MR model of clients' assessment of contractor performance

Appendix I6: Checking regression assumptions for MR model of architects' assessment of contractor performance

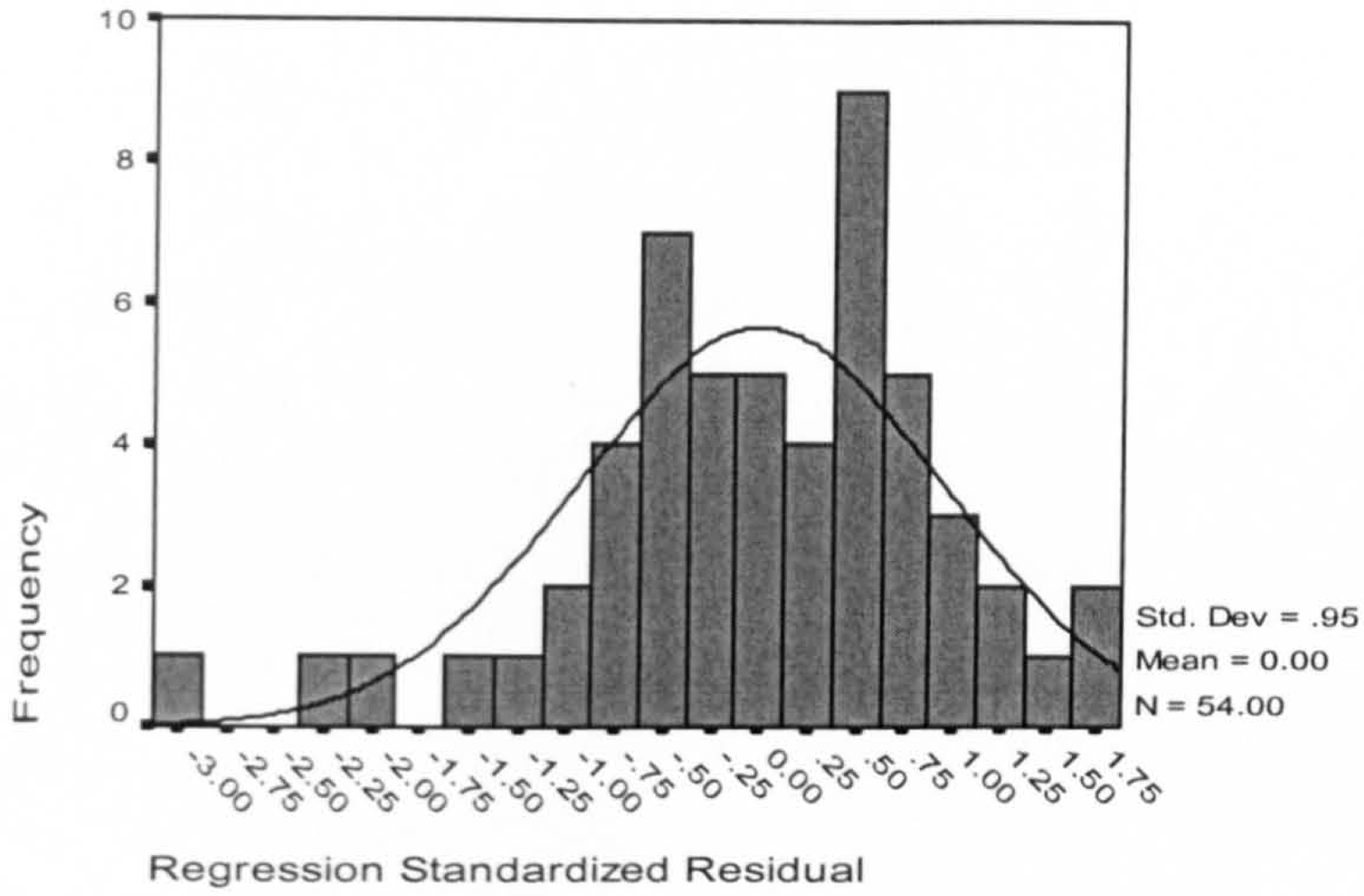

Figure I1.1 Histogram of standardized residuals for *totsat*

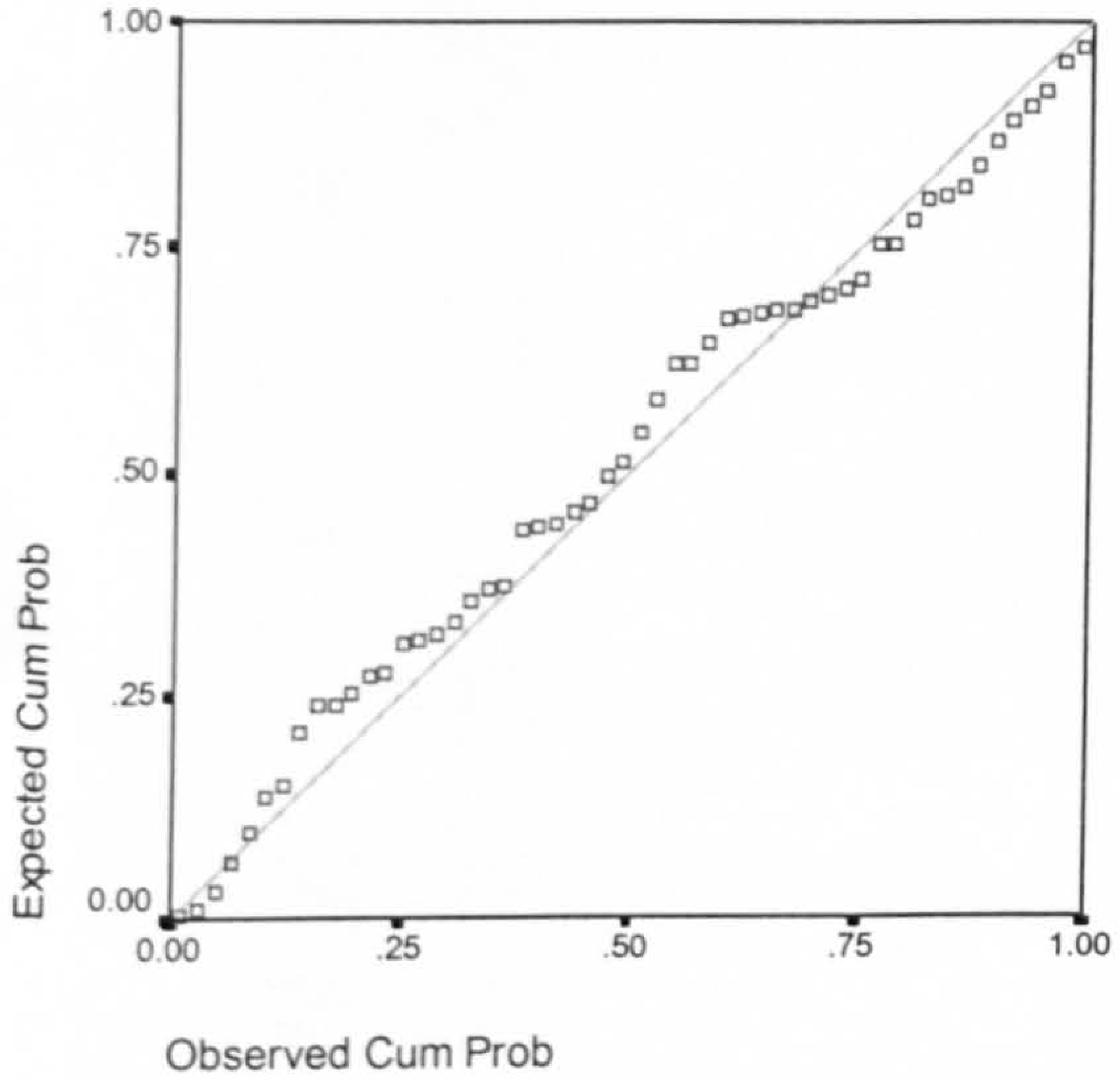

Figure I1.2 Normal probability (P-P) plot for *totsat*

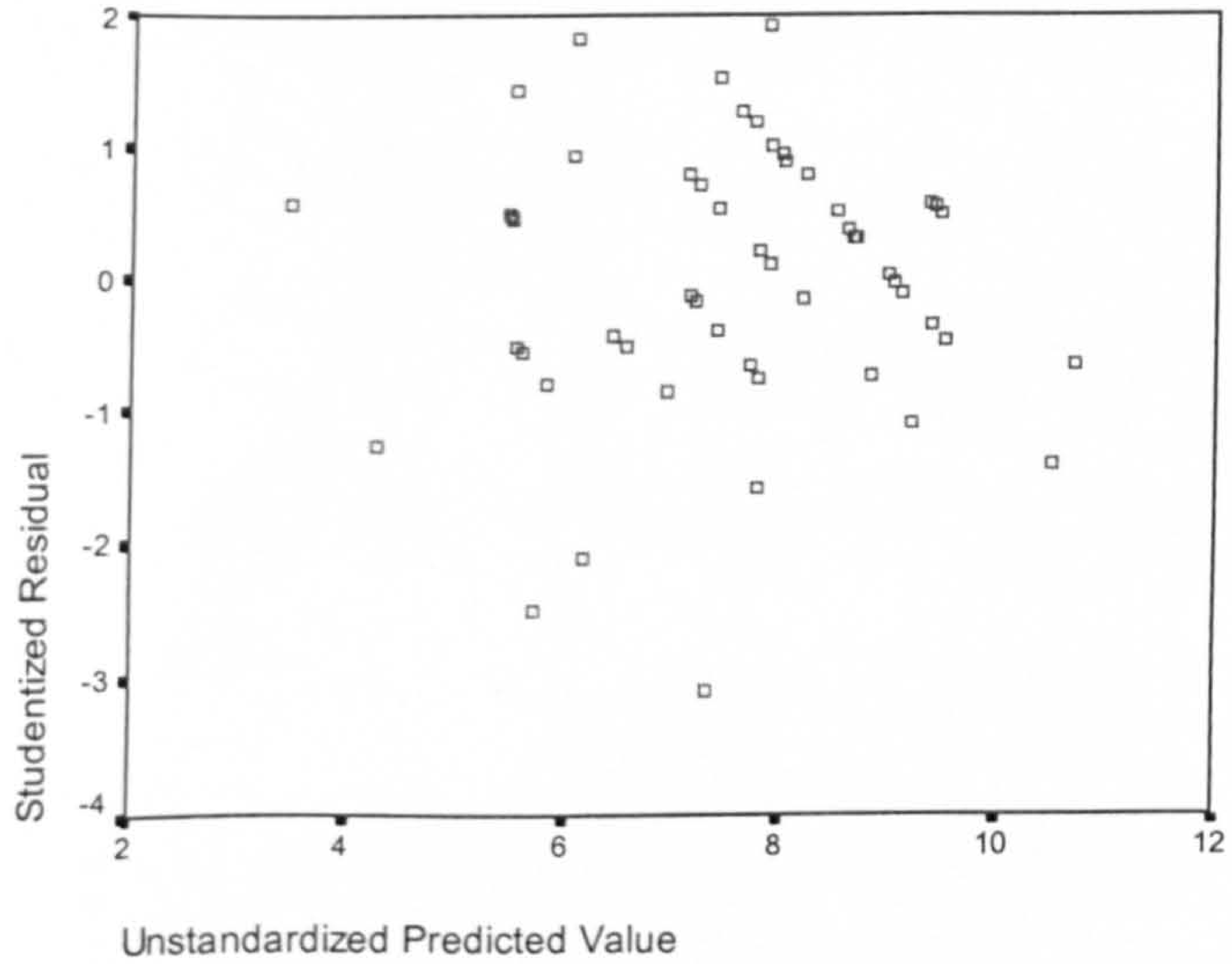

Figure I1.3 Studentized residuals versus predicted values for *totsat*

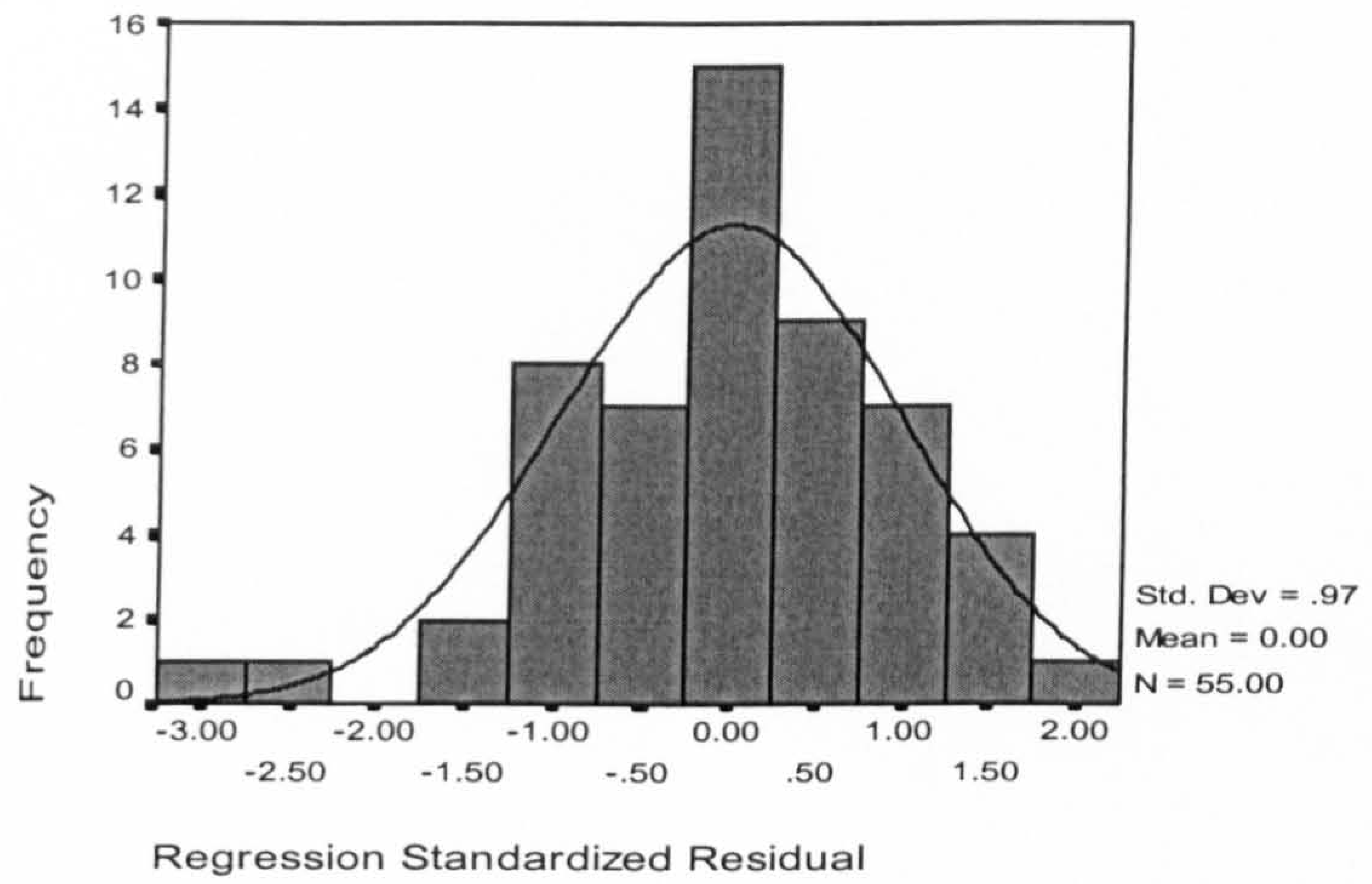

Figure I2.1 Histogram of standardized residuals for *totsat*

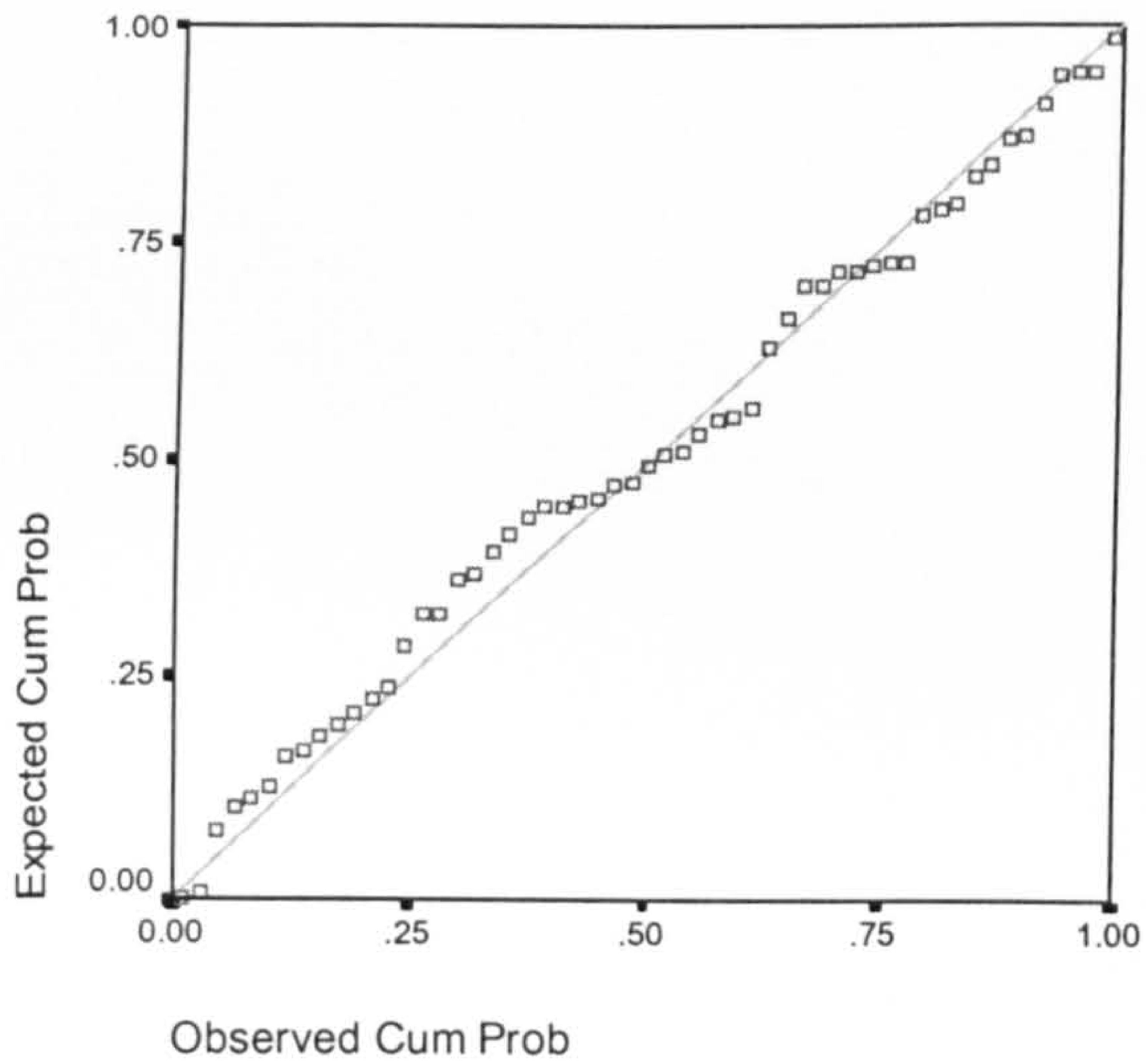

Figure I2.2 Normal probability (P-P) plot for *totsat*

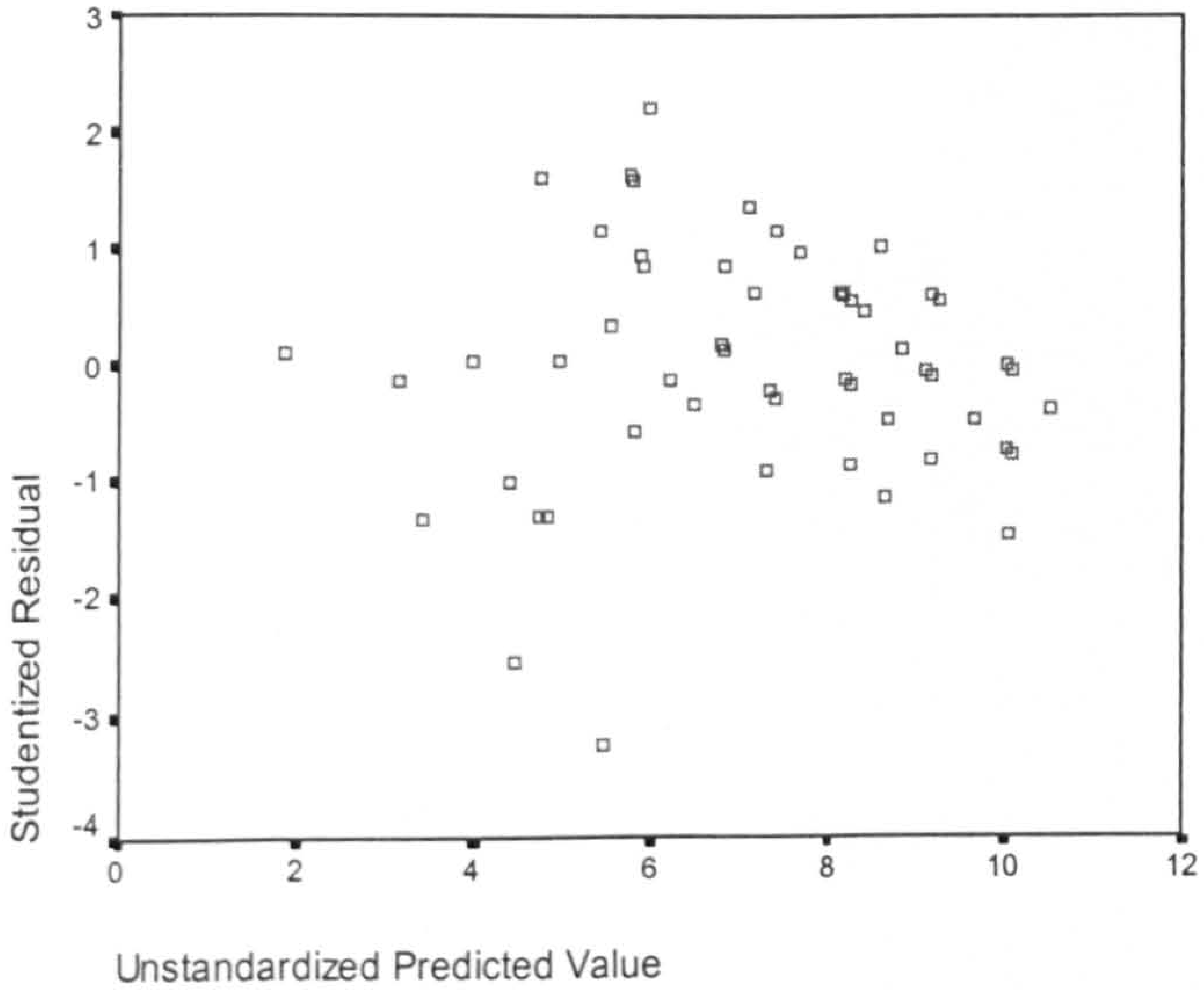

Figure I2.3 Studentized residuals versus predicted values for *totsat*

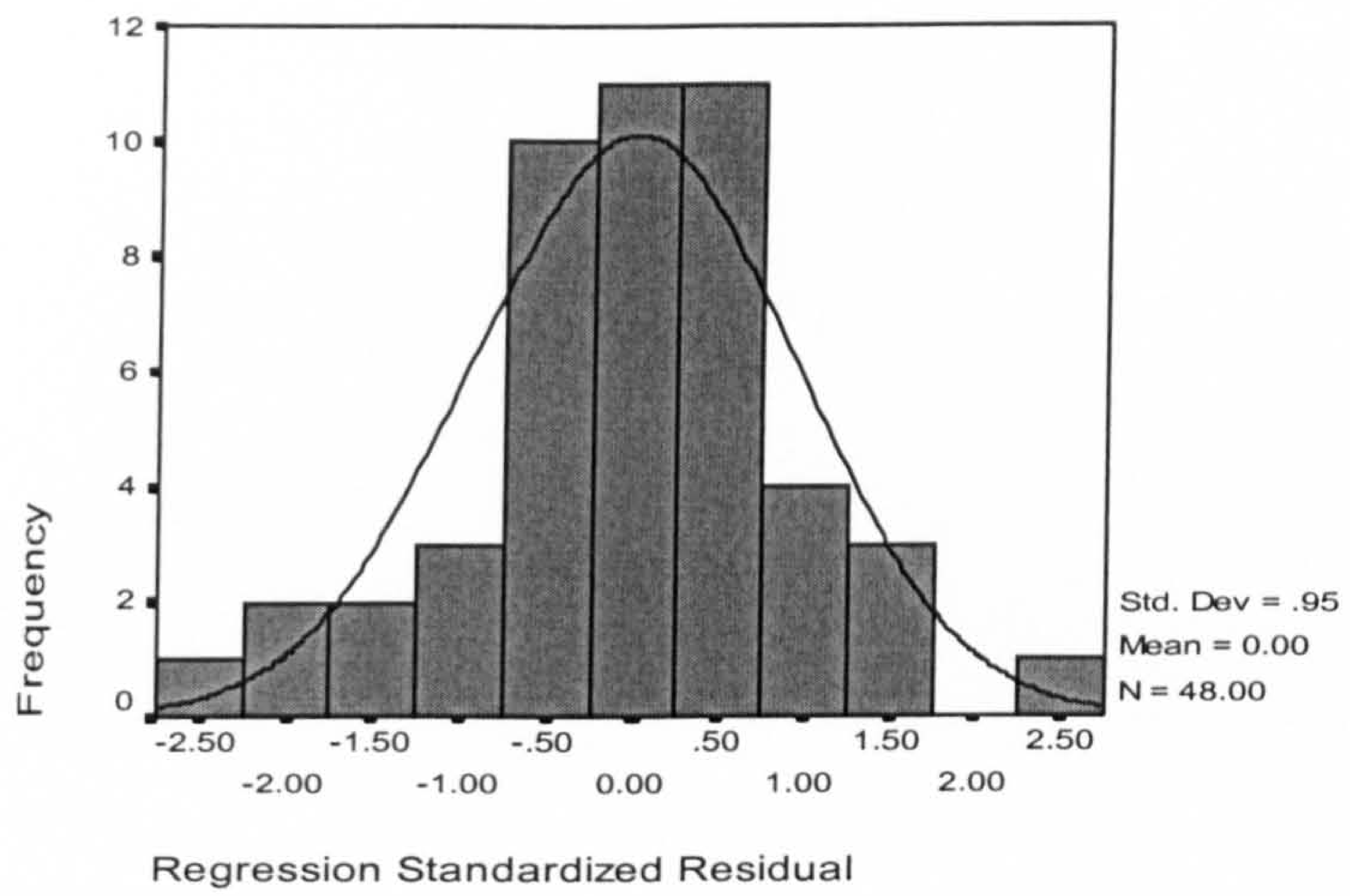

Figure I3.1 Histogram of standardized residuals for *totsat*

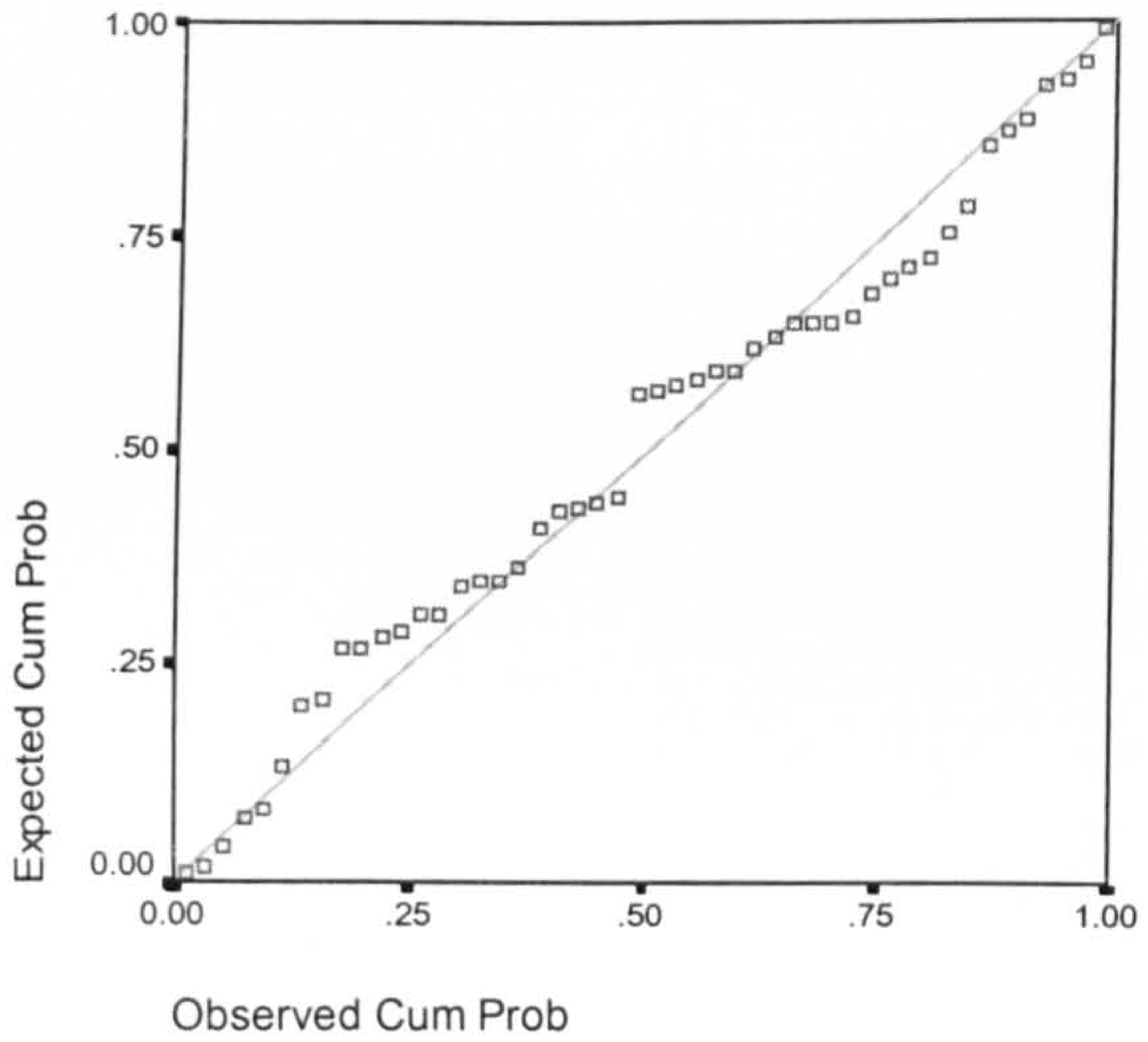

Figure I3.2 Normal probability (P-P) plot for *totsat*

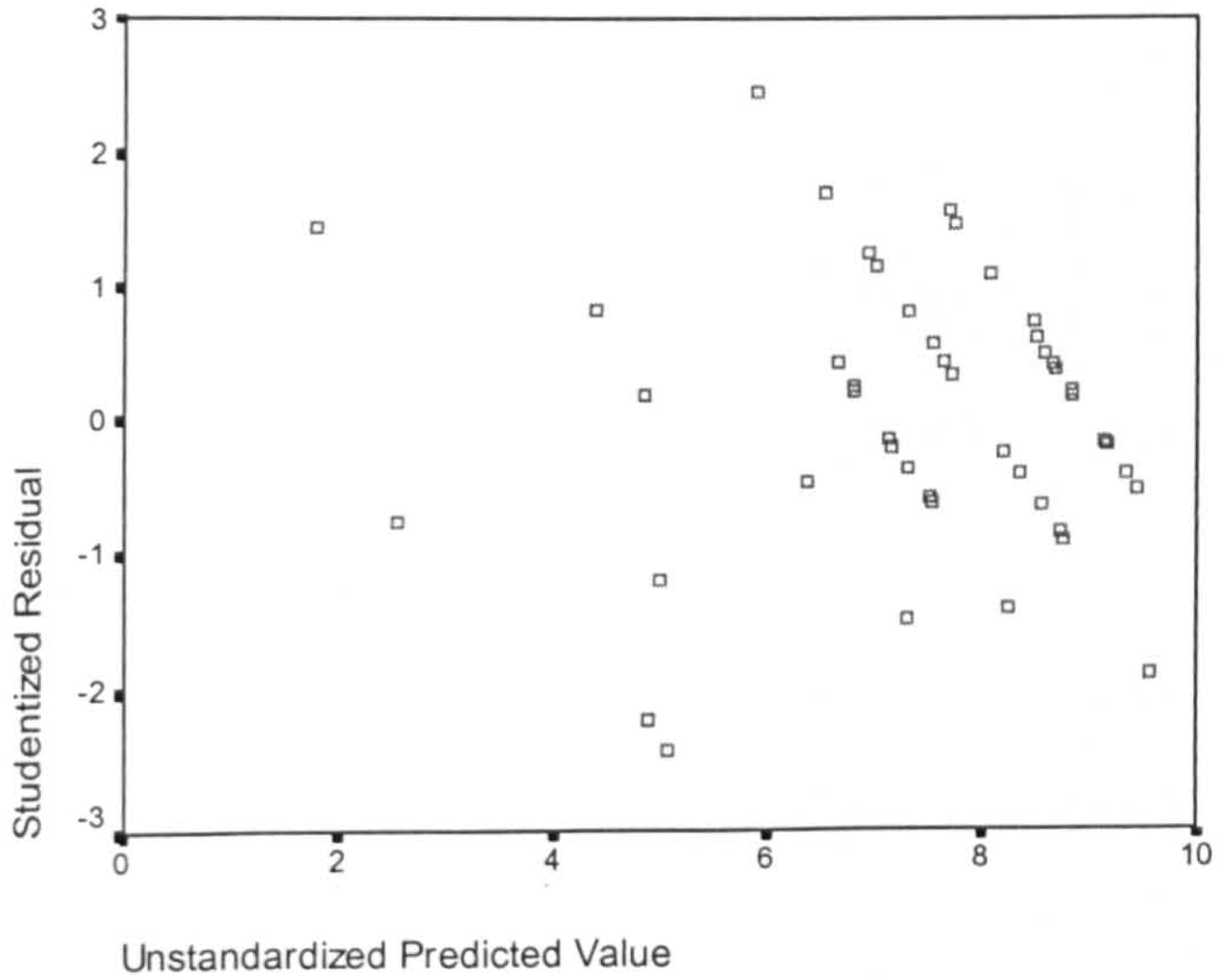

Figure I3.3 Studentized residuals versus predicted values for *totsat*

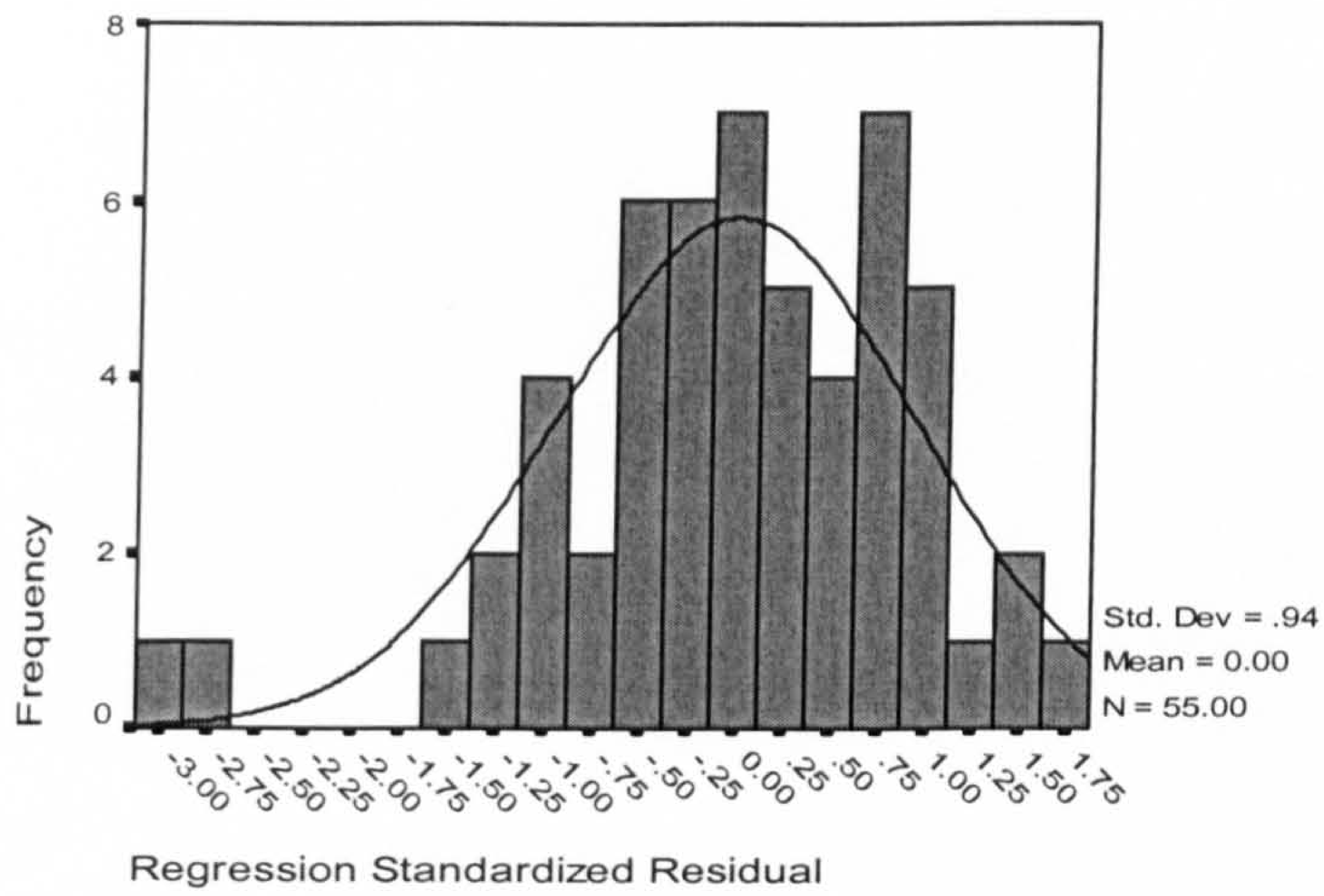

Figure I4.1 Histogram of standardized residuals for *totsat*

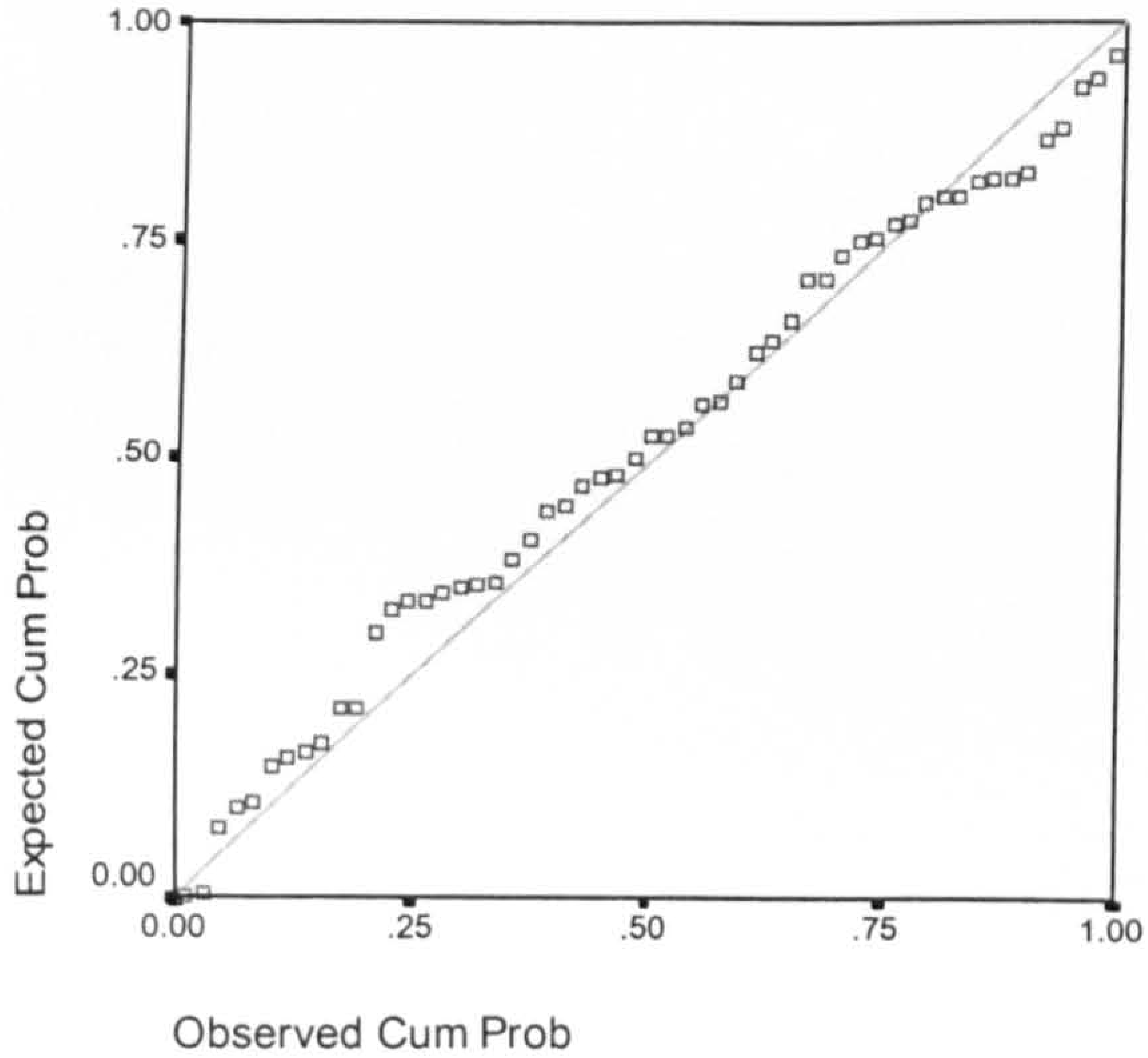

Figure I4.2 Normal probability (P-P) plot for *totsat*

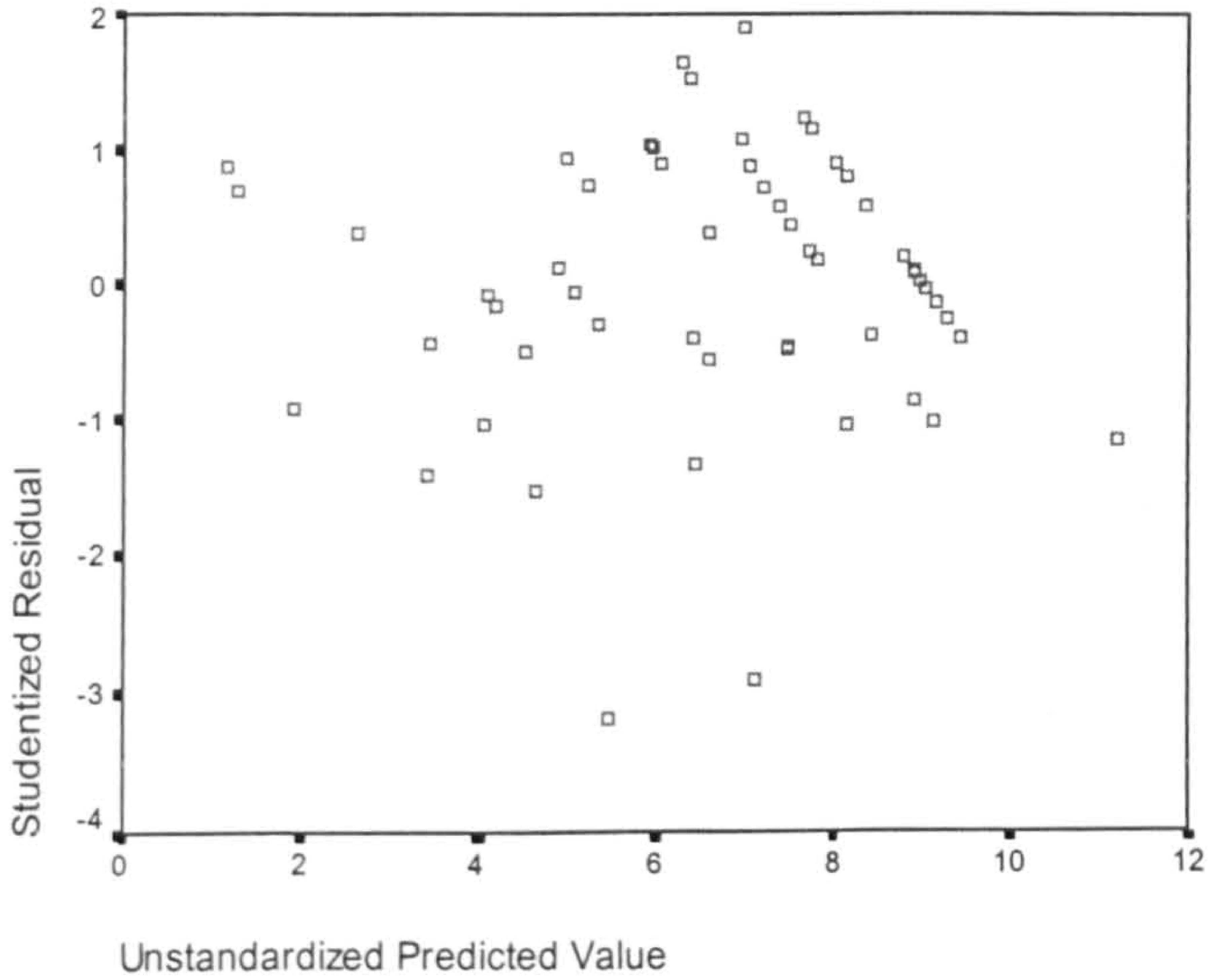

Figure I4.3 Studentized residuals versus predicted values for *totsat*

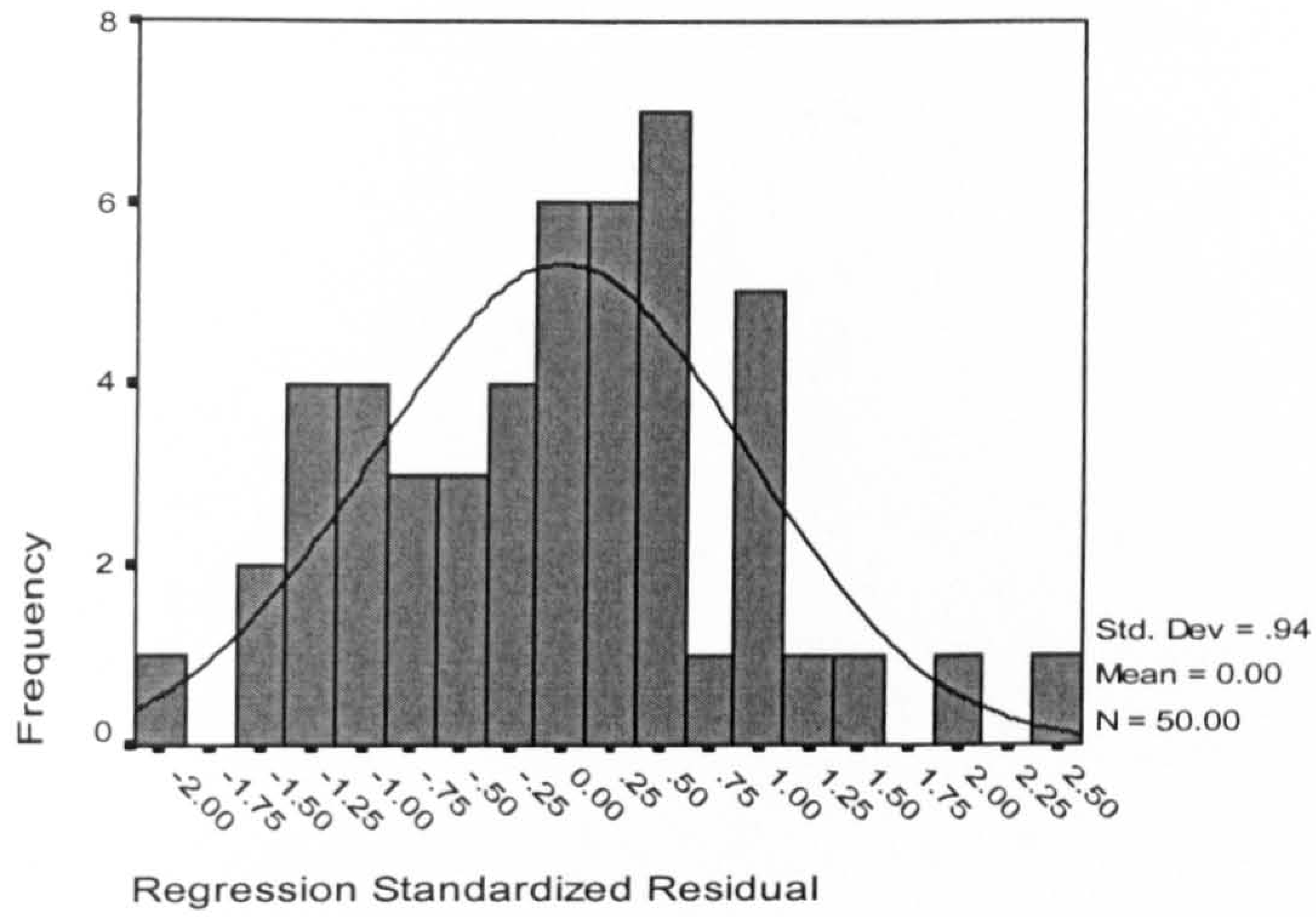

Figure I5.1 Histogram of standardized residuals for *totsat*

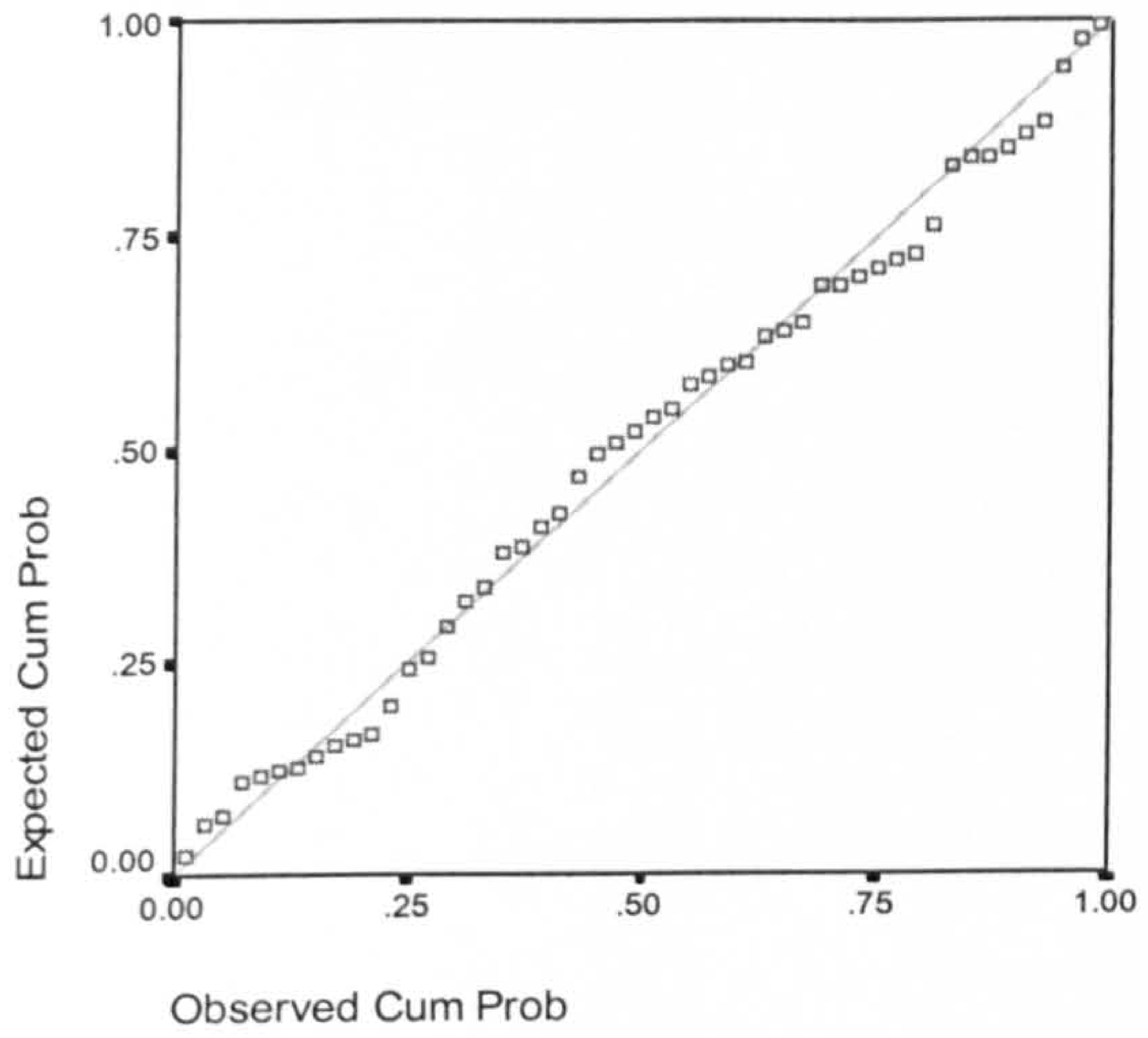

Figure I5.2 Normal probability (P-P) plot for *totsat*

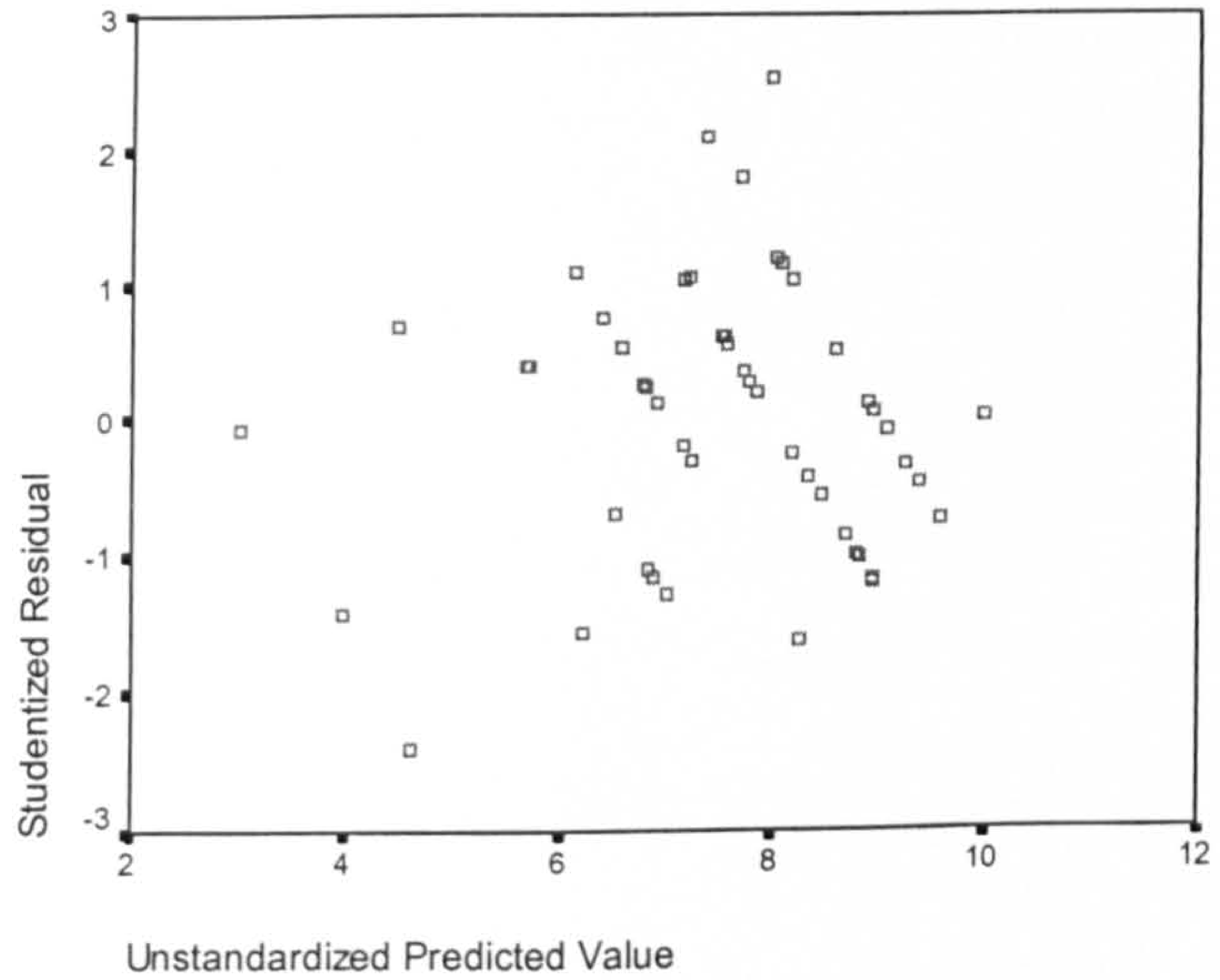

Figure I5.3 Studentized residuals versus predicted values for *totsat*

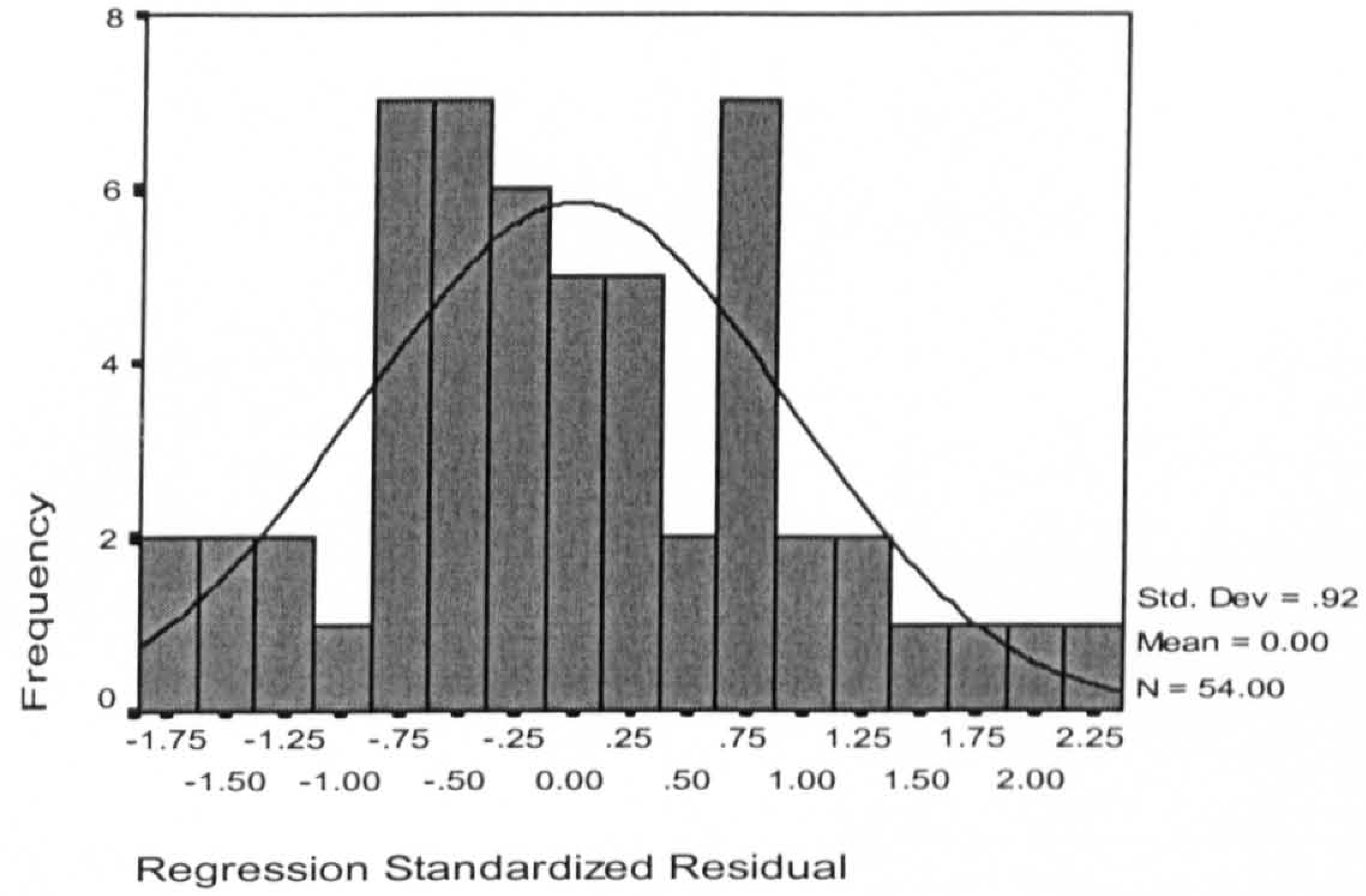

Figure I6.1 Histogram of standardized residuals for *totsat*

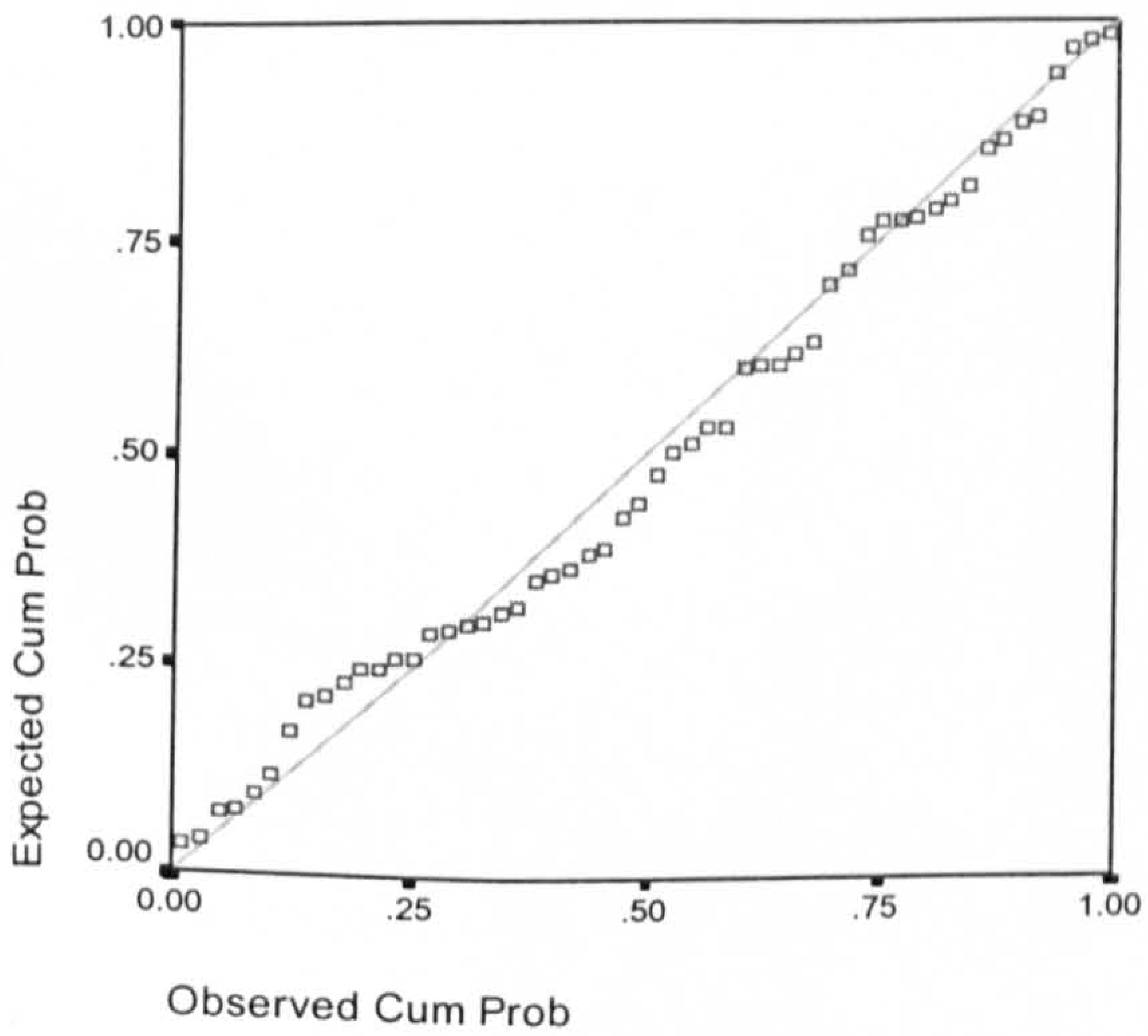

Figure I6.2 Normal probability (P-P) plot for *totsat*

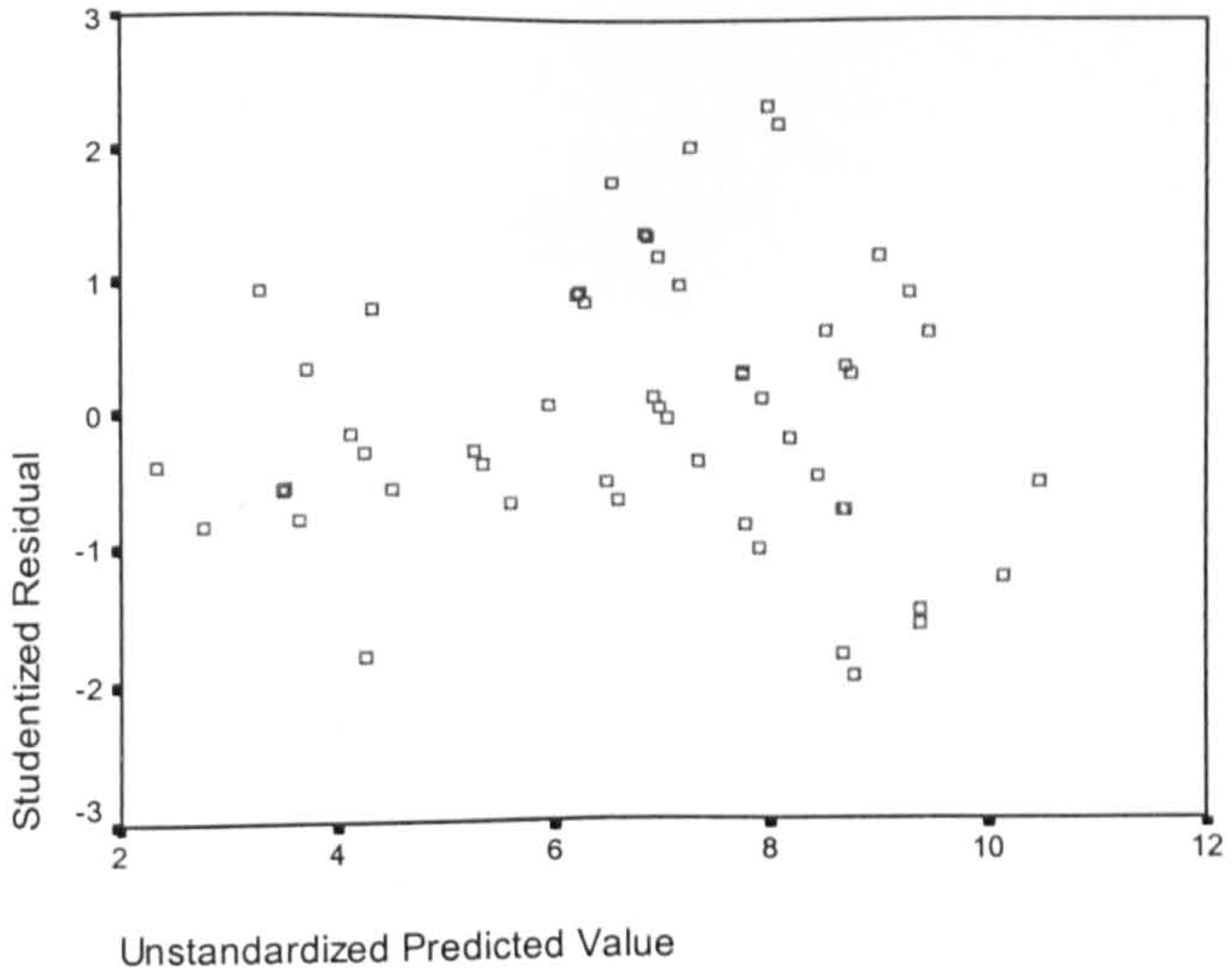

Figure I6.3 Studentized residuals versus predicted values for *totsat*

Appendix J:

Assessment of the Performance and Validation of the MR Models

Appendix J1: Assessment of the performance and validation of the MR model based on architects' assessment of client performance

Appendix J2: Assessment of the performance and validation of the MR model based on contractors' assessment of client performance

Appendix J3: Assessment of the performance and validation of the MR model based on clients' assessment of architect performance

Appendix J4: Assessment of the performance and validation of the MR model based on contractors' assessment of architect performance

Appendix J5: Assessment of the performance and validation of the MR model based on clients' assessment of contractor performance

Appendix J6: Assessment of the performance and validation of the MR model based on architects' assessment of contractor performance

Table J1.1 Assessment of the performance of the MR model for *totsat*

Actual x	Predicted p	Residual $x-p$	APE %	AD	Chi-square
7.0	7.1	-0.14	1.97	0.14	0.00265
8.0	9.2	-1.20	15.03	1.20	0.15709
9.0	10.5	-1.51	16.77	1.51	0.21672
9.0	8.2	0.78	8.72	0.78	0.07495
9.0	8.5	0.51	5.72	0.51	0.03125
3.0	4.3	-1.26	41.95	1.26	0.37192
6.0	6.6	-0.56	9.37	0.56	0.04814
9.0	8.7	0.35	3.89	0.35	0.01414
6.0	5.5	0.50	8.36	0.50	0.04579
9.0	8.0	1.02	11.37	1.02	0.13126
6.0	7.8	-1.77	29.44	1.77	0.40177
9.0	9.0	-0.02	0.24	0.02	0.00005
8.0	7.9	0.13	1.59	0.13	0.00206
10.0	9.4	0.64	6.40	0.64	0.04374
6.0	5.5	0.52	8.69	0.52	0.04967
8.0	7.1	0.87	10.94	0.87	0.10745
8.0	8.8	-0.82	10.30	0.82	0.07695
5.0	5.6	-0.58	11.62	0.58	0.06049
10.0	7.8	2.15	21.54	2.15	0.59140
9.0	7.9	1.13	12.57	1.13	0.16274
7.0	6.0	0.97	13.81	0.97	0.15492
6.0	5.5	0.53	8.86	0.53	0.05168
5.0	5.8	-0.82	16.38	0.82	0.11533
8.0	7.4	0.60	7.56	0.60	0.04948
6.0	6.9	-0.93	15.46	0.93	0.12423
8.0	7.8	0.23	2.88	0.23	0.00684
9.0	7.4	1.61	17.89	1.61	0.35084
10.0	10.7	-0.69	6.93	0.69	0.04485
9.0	9.4	-0.38	4.26	0.38	0.01569
9.0	8.6	0.42	4.68	0.42	0.02070
5.0	5.5	-0.54	10.88	0.54	0.05339
9.0	7.6	1.39	15.48	1.39	0.25521
9.0	9.1	-0.11	1.18	0.11	0.00123
7.0	7.7	-0.70	9.97	0.70	0.06332
7.0	7.4	-0.39	5.62	0.39	0.02092
9.0	9.5	-0.50	5.59	0.50	0.02668
9.0	8.0	0.99	10.95	0.99	0.12113
10.0	9.5	0.54	5.38	0.54	0.03056
8.0	6.1	1.93	24.06	1.93	0.61009
7.0	7.8	-0.77	11.04	0.77	0.07682
4.0	6.2	-2.18	54.47	2.18	0.76828
7.0	7.2	-0.18	2.57	0.18	0.00452
9.0	8.7	0.35	3.84	0.35	0.01382
4.0	7.3	-3.33	83.15	3.33	1.50995
9.0	7.7	1.27	14.14	1.27	0.20952
7.0	5.5	1.49	21.28	1.49	0.40260
6.0	6.4	-0.43	7.22	0.43	0.02920
8.0	8.2	-0.17	2.14	0.17	0.00360
10.0	9.4	0.59	5.92	0.59	0.03729
4.0	3.4	0.56	14.05	0.56	0.09184
8.0	7.2	0.79	9.85	0.79	0.08605
7.0	7.2	-0.19	2.68	0.19	0.00491
3.0	5.7	-2.73	90.86	2.73	1.29754
9.0	9.0	0.03	0.30	0.03	0.00008
			MAPE	**MAD**	**Total**
			13.85	**0.85**	**9.24333**

Degree of freedom = 54 - 1 = 53
Tab Chi-square (5%) = 70.993 > Calc Chi-square = 9.243
Pearson Correlation, r = 0.811, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table J1.2 Assessment of the validation of the MR model for *totsat*

Actual x	Predicted p	Residual $x-p$	APE %	AD	Chi-square
6.0	8.4	-2.37	39.51	2.37	0.67134
5.0	7.1	-2.07	41.43	2.07	0.60691
5.0	7.6	-2.57	51.30	2.57	0.86975
6.0	7.2	-1.19	19.77	1.19	0.19574
8.0	7.2	0.77	9.57	0.77	0.08094
4.0	5.7	-1.72	42.91	1.72	0.51543
8.0	7.8	0.19	2.41	0.19	0.00474
9.0	8.4	0.61	6.72	0.61	0.04363
3.0	3.8	-0.79	26.34	0.79	0.16477
10.0	5.5	4.50	45.03	4.50	3.68777
9.0	8.9	0.10	1.07	0.10	0.00104
7.0	6.5	0.47	6.70	0.47	0.03371
4.0	5.6	-1.59	39.66	1.59	0.45057
7.0	8.5	-1.46	20.84	1.46	0.25159
7.0	7.1	-0.13	1.80	0.13	0.00223
			MAPE	**MAD**	**Total**
			23.67	**1.37**	**7.58015**

Degree of freedom = 15 - 1 = 14
Tab Chi-square (5%) = 23.685 > Calc Chi-square = 7.580
Pearson Correlation, r = 0.524, p = 0.023 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table J2.1 Assessment of the performance of the MR model for *totsat*

Actual x	Predicted p	Residual $x-p$	APE %	AD	Chi-square
3.0	3.2	-0.16	5.31	0.16	0.00804
7.0	7.3	-0.31	4.49	0.31	0.01349
5.0	4.9	0.05	1.05	0.05	0.00056
10.0	9.2	0.76	7.62	0.76	0.06290
7.0	7.4	-0.39	5.54	0.39	0.02037
6.0	5.5	0.48	7.99	0.48	0.04167
9.0	10.0	-1.02	11.28	1.02	0.10287
9.0	9.7	-0.66	7.37	0.66	0.04553
8.0	8.2	-0.24	2.99	0.24	0.00694
9.0	9.2	-0.16	1.82	0.16	0.00293
9.0	8.2	0.76	8.46	0.76	0.07028
8.0	8.2	-0.20	2.46	0.20	0.00471
4.0	4.0	0.03	0.84	0.03	0.00029
7.0	8.2	-1.23	17.62	1.23	0.18469
9.0	7.4	1.62	17.98	1.62	0.35462
9.0	7.7	1.34	14.89	1.34	0.23452
8.0	6.8	1.19	14.82	1.19	0.20613
9.0	9.1	-0.09	1.00	0.09	0.00089
7.0	5.4	1.61	22.99	1.61	0.48054
9.0	6.0	3.04	33.74	3.04	1.54585
3.0	4.4	-1.39	46.39	1.39	0.44108
8.0	5.8	2.22	27.70	2.22	0.84927
9.0	8.4	0.61	6.81	0.61	0.04485
9.0	7.1	1.90	21.13	1.90	0.50942
5.0	5.8	-0.81	16.20	0.81	0.11296
9.0	8.8	0.19	2.09	0.19	0.00400
7.0	6.8	0.23	3.30	0.23	0.00788
10.0	10.0	-0.02	0.15	0.02	0.00002
6.0	6.5	-0.48	8.04	0.48	0.03594
7.0	5.9	1.12	16.03	1.12	0.21408
1.0	4.5	-3.47	346.56	3.47	2.68957
8.0	5.7	2.26	28.22	2.26	0.88771
9.0	8.2	0.83	9.28	0.83	0.08535
7.0	5.9	1.15	16.37	1.15	0.22432
6.0	7.3	-1.31	21.80	1.31	0.23417
7.0	4.7	2.26	32.24	2.26	1.07364
3.0	4.8	-1.83	60.92	1.83	0.69179
8.0	10.0	-2.05	25.57	2.05	0.41657
8.0	8.7	-0.66	8.31	0.66	0.05097
10.0	8.6	1.41	14.09	1.41	0.23118
8.0	9.2	-1.16	14.55	1.16	0.14783
7.0	6.8	0.18	2.52	0.18	0.00455
10.0	9.2	0.84	8.36	0.84	0.07628
2.0	3.4	-1.42	71.25	1.42	0.59284
6.0	6.2	-0.20	3.25	0.20	0.00614
1.0	5.5	-4.46	446.44	4.46	3.64736
10.0	10.1	-0.09	0.89	0.09	0.00078
3.0	4.7	-1.74	58.12	1.74	0.64085
2.0	1.9	0.12	6.16	0.12	0.00809
8.0	7.1	0.87	10.84	0.87	0.10552
7.0	8.6	-1.63	23.35	1.63	0.30936
9.0	8.1	0.86	9.52	0.86	0.09005
9.0	10.1	-1.09	12.10	1.09	0.11751
10.0	10.5	-0.51	5.14	0.51	0.02516
9.0	8.1	0.88	9.75	0.88	0.09490
			MAPE	**MAD**	**Total**
			28.79	**1.05**	**18.05982**

Degree of freedom = 55 - 1 = 54
Tab Chi-square (5%) = 72.153 > Calc Chi-square = 18.060
Pearson Correlation, r = 0.825, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table J2.2 Assessment of the validation of the MR model for *totsat*

Actual x	Predicted p	Residual $x\text{-}p$	APE %	AD	Chi-square
7.0	6.2	0.79	11.31	0.79	0.10100
9.0	8.6	0.41	4.53	0.41	0.01937
6.0	7.3	-1.29	21.54	1.29	0.22906
8.0	6.7	1.25	15.65	1.25	0.23237
8.0	8.7	-0.66	8.31	0.66	0.05104
4.0	4.9	-0.89	22.30	0.89	0.16265
10.0	6.4	3.58	35.81	3.58	1.99795
5.0	6.2	-1.17	23.40	1.17	0.22186
2.0	5.2	-3.18	158.77	3.18	1.94820
6.0	4.9	1.08	17.98	1.08	0.23637
10.0	10.4	-0.44	4.42	0.44	0.01871
5.0	6.7	-1.69	33.72	1.69	0.42512
8.0	7.2	0.83	10.40	0.83	0.09657
8.0	8.7	-0.66	8.31	0.66	0.05104
8.0	7.7	0.26	3.25	0.26	0.00873
6.0	5.4	0.59	9.87	0.59	0.06490
3.0	5.7	-2.68	89.31	2.68	1.26400
6.0	8.2	-2.17	36.10	2.17	0.57452
9.0	6.5	2.48	27.52	2.48	0.94060
4.0	2.8	1.16	29.12	1.16	0.47848
8.0	6.1	1.86	23.28	1.86	0.56510
5.0	7.6	-2.55	51.02	2.55	0.86174
6.0	6.9	-0.91	15.12	0.91	0.11912
7.0	5.1	1.85	26.49	1.85	0.66844
6.0	7.0	-0.96	16.02	0.96	0.13267
			MAPE	**MAD**	**Total**
			28.14	**1.42**	**11.46960**

Degree of freedom = 25 - 1 = 24
Tab Chi-square (5%) = 36.415 > Calc Chi-square = 11.470
Pearson Correlation, r = 0.588, p = 0.001 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table J3.1 Assessment of the performance of the MR model for *totsat*

Actual x	Predicted p	Residual $x-p$	APE %	AD	Chi-square
5.0	4.8	0.17	3.33	0.17	0.00574
4.0	5.0	-0.99	24.84	0.99	0.19771
2.0	1.8	0.22	11.01	0.22	0.02724
8.0	7.6	0.37	4.59	0.37	0.01769
7.0	7.5	-0.52	7.43	0.52	0.03600
8.0	9.6	-1.57	19.57	1.57	0.25627
9.0	7.7	1.27	14.15	1.27	0.21005
9.0	8.1	0.94	10.44	0.94	0.10958
8.0	8.4	-0.35	4.42	0.35	0.01496
3.0	5.1	-2.07	69.02	2.07	0.84563
9.0	8.8	0.16	1.76	0.16	0.00283
9.0	8.6	0.35	3.92	0.35	0.01443
7.0	6.8	0.19	2.78	0.19	0.00557
9.0	9.4	-0.45	4.99	0.45	0.02131
7.0	8.2	-1.23	17.64	1.23	0.18513
8.0	7.5	0.47	5.90	0.47	0.02963
8.0	8.5	-0.55	6.86	0.55	0.03518
8.0	7.0	1.01	12.57	1.01	0.14452
8.0	8.7	-0.72	9.04	0.72	0.05992
9.0	8.8	0.18	1.99	0.18	0.00362
9.0	7.7	1.33	14.76	1.33	0.22992
6.0	7.3	-1.29	21.56	1.29	0.22942
8.0	7.7	0.28	3.54	0.28	0.01037
8.0	8.2	-0.21	2.57	0.21	0.00514
9.0	8.6	0.43	4.79	0.43	0.02170
8.0	5.9	2.13	26.65	2.13	0.77440
5.0	4.4	0.62	12.34	0.62	0.08685
9.0	9.4	-0.45	4.99	0.45	0.02131
8.0	8.7	-0.75	9.32	0.75	0.06355
9.0	9.4	-0.35	3.89	0.35	0.01313
9.0	8.5	0.51	5.67	0.51	0.03067
7.0	7.5	-0.50	7.14	0.50	0.03333
7.0	7.2	-0.15	2.18	0.15	0.00325
9.0	8.7	0.31	3.47	0.31	0.01123
9.0	9.2	-0.16	1.73	0.16	0.00264
9.0	8.6	0.35	3.92	0.35	0.01443
7.0	7.1	-0.12	1.70	0.12	0.00199
3.0	4.9	-1.87	62.45	1.87	0.72028
7.0	7.3	-0.31	4.49	0.31	0.01348
9.0	9.1	-0.14	1.50	0.14	0.00200
8.0	7.3	0.71	8.83	0.71	0.06842
8.0	6.5	1.49	18.56	1.49	0.33853
6.0	6.4	-0.37	6.11	0.37	0.02112
7.0	6.6	0.35	5.02	0.35	0.01857
8.0	6.9	1.08	13.45	1.08	0.16717
9.0	8.5	0.54	5.97	0.54	0.03406
7.0	6.8	0.22	3.12	0.22	0.00703
2.0	2.6	-0.55	27.65	0.55	0.11976
			MAPE	**MAD**	**Total**
			10.91	**0.65**	**5.28676**

Degree of freedom = 48 - 1 = 47
Tab Chi-square (5%) = 64.001 > Calc Chi-square = 5.287
Pearson Correlation, r = 0.896, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table J3.2 Assessment of the validation of the MR model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square
8.0	6.0	2.02	25.25	2.02	0.68210
9.0	8.7	0.26	2.89	0.26	0.00773
6.0	7.3	-1.31	21.82	1.31	0.23443
8.0	8.8	-0.78	9.79	0.78	0.06980
8.0	7.3	0.75	9.31	0.75	0.07650
8.0	8.9	-0.91	11.43	0.91	0.09372
6.0	6.5	-0.45	7.53	0.45	0.03167
10.0	9.1	0.89	8.91	0.89	0.08715
3.0	5.8	-2.78	92.58	2.78	1.33519
8.0	5.5	2.55	31.88	2.55	1.19312
5.0	5.0	0.00	0.04	0.00	0.00000
7.0	5.9	1.14	16.26	1.14	0.22090
9.0	7.9	1.10	12.27	1.10	0.15436
8.0	4.7	3.26	40.72	3.26	2.23805
8.0	7.0	1.00	12.50	1.00	0.14292
7.0	5.7	1.27	18.10	1.27	0.28015
8.0	8.4	-0.43	5.33	0.43	0.02154
8.0	8.5	-0.55	6.81	0.55	0.03476
5.0	7.3	-2.31	46.20	2.31	0.72997
5.0	7.8	-2.76	55.28	2.76	0.98399
9.0	7.8	1.22	13.56	1.22	0.19130
			MAPE	**MAD**	**Total**
			21.35	**1.32**	**8.80938**

Degree of freedom = 21 - 1 = 20
Tab Chi-square (5%) = 31.410 > Calc Chi-square = 8.809
Pearson Correlation, r = 0.453, p = 0.020 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table J4.1 Assessment of the performance of the MR model for *totsat*

Actual x	Predicted p	Residual $x-p$	APE %	AD	Chi-square
6.0	6.6	-0.60	10.03	0.60	0.05482
5.0	5.3	-0.34	6.75	0.34	0.02133
7.0	7.5	-0.49	6.96	0.49	0.03172
8.0	9.1	-1.12	14.06	1.12	0.13857
9.0	9.0	-0.05	0.54	0.05	0.00027
3.0	4.1	-1.07	35.71	1.07	0.28183
9.0	9.1	-0.15	1.66	0.15	0.00244
10.0	11.2	-1.21	12.07	1.21	0.12995
8.0	7.4	0.62	7.78	0.62	0.05254
9.0	9.4	-0.44	4.89	0.44	0.02048
8.0	7.8	0.19	2.34	0.19	0.00450
7.0	7.5	-0.49	7.00	0.49	0.03203
6.0	5.2	0.78	12.99	0.78	0.11638
8.0	6.9	1.05	13.16	1.05	0.15948
9.0	7.7	1.33	14.77	1.33	0.23025
9.0	7.7	1.25	13.92	1.25	0.20265
8.0	8.4	-0.42	5.22	0.42	0.02074
8.0	8.9	-0.91	11.40	0.91	0.09338
9.0	9.0	0.01	0.15	0.01	0.00002
6.0	6.4	-0.42	7.07	0.42	0.02801
9.0	8.9	0.09	0.96	0.09	0.00084
3.0	4.6	-1.64	54.64	1.64	0.57912
5.0	6.5	-1.46	29.12	1.46	0.32839
7.0	6.0	0.97	13.85	0.97	0.15575
2.0	5.5	-3.47	173.34	3.47	2.19841
7.0	8.2	-1.16	16.58	1.16	0.16500
8.0	6.4	1.62	20.31	1.62	0.41409
2.0	1.3	0.71	35.56	0.71	0.39235
4.0	7.1	-3.10	77.60	3.10	1.35633
3.0	2.6	0.37	12.23	0.37	0.05112
2.0	3.4	-1.42	71.17	1.42	0.59177
4.0	4.1	-0.09	2.19	0.09	0.00187
8.0	7.1	0.94	11.72	0.94	0.12455
8.0	7.2	0.78	9.77	0.78	0.08465
9.0	8.4	0.63	6.97	0.63	0.04704
8.0	7.5	0.48	5.96	0.48	0.03020
9.0	8.8	0.20	2.25	0.20	0.00467
1.0	1.9	-0.91	90.94	0.91	0.43314
6.0	5.0	1.03	17.12	1.03	0.21221
2.0	1.1	0.85	42.72	0.85	0.63706
9.0	7.0	2.00	22.25	2.00	0.57293
7.0	5.9	1.05	15.03	1.05	0.18602
3.0	3.5	-0.45	15.11	0.45	0.05950
9.0	8.2	0.85	9.41	0.85	0.08798
7.0	6.6	0.41	5.79	0.41	0.02490
7.0	5.9	1.08	15.42	1.08	0.19682
9.0	9.3	-0.27	2.97	0.27	0.00771
8.0	6.3	1.71	21.41	1.71	0.46680
4.0	4.5	-0.52	12.96	0.52	0.05947
5.0	4.9	0.11	2.24	0.11	0.00258
8.0	7.7	0.26	3.31	0.26	0.00904
9.0	8.9	0.09	0.99	0.09	0.00088
9.0	8.0	0.96	10.71	0.96	0.11572
4.0	4.2	-0.18	4.39	0.18	0.00737
5.0	5.1	-0.06	1.22	0.06	0.00073
			MAPE	MAD	Total
			18.67	**0.82**	**11.22841**

Degree of freedom = 55 - 1 = 54
Tab Chi-square (5%) = 72.153 > Calc Chi-square = 11.228
Pearson Correlation, r = 0.898, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table J4.2 Assessment of the validation of the MR model for *totsat*

Actual x	Predicted p	Residual $x\text{-}p$	APE %	AD	Chi-square
3.0	4.7	-1.73	57.50	1.73	0.62976
4.0	4.0	-0.03	0.85	0.03	0.00029
4.0	7.0	-2.96	73.95	2.96	1.25751
4.0	2.0	1.95	48.78	1.95	1.85769
10.0	11.2	-1.19	11.89	1.19	0.12635
6.0	6.1	-0.15	2.48	0.15	0.00361
8.0	6.8	1.24	15.46	1.24	0.22626
7.0	7.2	-0.15	2.19	0.15	0.00327
8.0	7.9	0.07	0.88	0.07	0.00062
4.0	3.4	0.60	14.98	0.60	0.10550
3.0	3.2	-0.16	5.43	0.16	0.00840
0.0	4.4	-4.36		4.36	4.36000
6.0	6.9	-0.85	14.23	0.85	0.10641
3.0	3.1	-0.13	4.33	0.13	0.00540
5.0	4.6	0.44	8.86	0.44	0.04307
7.0	5.7	1.32	18.90	1.32	0.30832
7.0	3.3	3.74	53.39	3.74	4.27986
7.0	5.8	1.16	16.63	1.16	0.23216
			MAPE	**MAD**	**Total**
			20.63	**1.24**	**13.55446**

Degree of freedom = 18 - 1 = 17
Tab Chi-square (5%) = 27.587 > Calc Chi-square = 13.554
Pearson Correlation, r = 0.698, p = 0.001 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table J5.1 Assessment of the performance of the MR model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square	Predicted w/ constant	Residual	APE %	AD	Chi-square
9.0	7.7	1.30	14.39	1.30	0.21768	6.5	2.53	28.13	2.53	0.99082
8.0	7.5	0.46	5.75	0.46	0.02801	6.3	1.70	21.23	1.70	0.45763
8.0	7.8	0.22	2.70	0.22	0.00600	6.5	1.46	18.19	1.46	0.32361
8.0	8.8	-0.79	9.93	0.79	0.07173	7.6	0.44	5.54	0.44	0.02602
3.0	3.0	-0.01	0.39	0.01	0.00005	1.8	1.23	41.15	1.23	0.86298
7.0	6.8	0.20	2.92	0.20	0.00616	5.6	1.44	20.59	1.44	0.37381
8.0	7.2	0.78	9.79	0.78	0.08507	6.0	2.02	25.25	2.02	0.68254
9.0	9.0	0.04	0.46	0.04	0.00019	7.7	1.28	14.21	1.28	0.21189
10.0	10.0	0.01	0.12	0.01	0.00001	8.8	1.25	12.50	1.25	0.17854
9.0	9.6	-0.57	6.36	0.57	0.03423	8.3	0.67	7.39	0.67	0.05312
8.0	9.0	-0.96	11.95	0.96	0.10203	7.7	0.28	3.51	0.28	0.01024
7.0	7.2	-0.16	2.27	0.16	0.00352	5.9	1.08	15.41	1.08	0.19661
9.0	8.1	0.91	10.11	0.91	0.10239	6.9	2.15	23.87	2.15	0.67366
3.0	4.6	-1.63	54.44	1.63	0.57575	3.4	-0.40	13.19	0.40	0.04609
8.0	8.5	-0.45	5.68	0.45	0.02441	7.2	0.78	9.80	0.78	0.08519
9.0	9.1	-0.07	0.75	0.07	0.00051	7.8	1.17	13.00	1.17	0.17478
7.0	6.4	0.59	8.40	0.59	0.05392	5.2	1.83	26.10	1.83	0.64501
10.0	8.0	2.01	20.09	2.01	0.50490	6.8	3.25	32.46	3.25	1.56016
6.0	6.9	-0.89	14.77	0.89	0.11404	5.6	0.35	5.88	0.35	0.02204
7.0	6.9	0.08	1.10	0.08	0.00086	5.7	1.32	18.80	1.32	0.30469
6.0	5.7	0.29	4.89	0.29	0.01505	4.5	1.53	25.49	1.53	0.52343
8.0	7.2	0.82	10.31	0.82	0.09485	5.9	2.06	25.78	2.06	0.71661
6.0	6.5	-0.54	9.01	0.54	0.04468	5.3	0.70	11.63	0.70	0.09189
7.0	8.3	-1.27	18.16	1.27	0.19527	7.0	-0.03	0.47	0.03	0.00015
9.0	8.6	0.41	4.55	0.41	0.01949	7.4	1.65	18.31	1.65	0.36931
9.0	9.2	-0.24	2.72	0.24	0.00649	8.0	0.99	11.02	0.99	0.12279
8.0	7.6	0.43	5.43	0.43	0.02496	6.3	1.67	20.90	1.67	0.44168
8.0	8.7	-0.69	8.65	0.69	0.05504	7.5	0.55	6.84	0.55	0.04013
9.0	8.0	0.96	10.69	0.96	0.11527	6.8	2.20	24.45	2.20	0.71180
8.0	8.2	-0.19	2.38	0.19	0.00444	7.0	1.05	13.08	1.05	0.15758
7.0	6.1	0.86	12.26	0.86	0.11987	4.9	2.10	29.94	2.10	0.89584
3.0	4.0	-0.98	32.53	0.98	0.23957	2.7	0.26	8.70	0.26	0.02486
8.0	7.7	0.27	3.44	0.27	0.00978	6.5	1.51	18.91	1.51	0.35280
8.0	8.3	-0.34	4.29	0.34	0.01414	7.1	0.89	11.17	0.89	0.11237
8.0	7.5	0.48	6.06	0.48	0.03128	6.3	1.72	21.53	1.72	0.47280
9.0	8.9	0.09	1.05	0.09	0.00100	7.7	1.33	14.81	1.33	0.23161
8.0	8.8	-0.82	10.20	0.82	0.07549	7.6	0.42	5.28	0.42	0.02357
6.0	6.8	-0.84	14.04	0.84	0.10374	5.6	0.39	6.56	0.39	0.02766
5.0	4.5	0.50	10.00	0.50	0.05554	3.3	1.74	34.77	1.74	0.92675
9.0	8.2	0.82	9.09	0.82	0.08183	6.9	2.06	22.85	2.06	0.60892
8.0	7.8	0.16	1.95	0.16	0.00309	6.6	1.39	17.43	1.39	0.29421
9.0	9.4	-0.38	4.20	0.38	0.01523	8.1	0.86	9.55	0.86	0.09082
9.0	7.4	1.64	18.24	1.64	0.36618	6.1	2.88	32.00	2.88	1.35574
6.0	5.7	0.31	5.24	0.31	0.01740	4.4	1.55	25.87	1.55	0.54173
6.0	7.0	-1.01	16.86	1.01	0.14592	5.8	0.23	3.78	0.23	0.00892
7.0	6.6	0.41	5.84	0.41	0.02533	5.4	1.65	23.53	1.65	0.50675
8.0	8.9	-0.93	11.68	0.93	0.09769	7.7	0.30	3.79	0.30	0.01195
7.0	7.3	-0.25	3.63	0.25	0.00890	6.0	0.98	14.05	0.98	0.16068
7.0	6.8	0.18	2.58	0.18	0.00479	5.6	1.42	20.27	1.42	0.36056
5.0	6.2	-1.22	24.46	1.22	0.24031	5.0	0.02	0.32	0.02	0.00005
			MAPE	MAD	Total			MAPE	MAD	Total
			9.14	0.61	4.16410			16.79	1.26	18.06338

Degree of freedom = 50 - 1 = 49

Tab Chi-square (5%) = 66.338 > Calc Chi-square = 4.164
Pearson Correlation, r = 0.884, p = 0.000 (1-tailed)

Tab Chi-square (5%) = 66.338 > Calc Chi-square = 18.063
Pearson Correlation, r = 0.886, p = 0.000 (1-tailed)

Table J5.2 Assessment of the validation of the MR model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square
6.0	7.3	-1.32	21.96	1.32	0.23728
8.0	8.1	-0.14	1.77	0.14	0.00247
7.0	6.7	0.29	4.13	0.29	0.01243
4.0	7.1	-3.12	78.07	3.12	1.36911
5.0	7.3	-2.34	46.82	2.34	0.74664
5.0	6.1	-1.08	21.69	1.08	0.19337
9.0	9.5	-0.49	5.39	0.49	0.02482
6.0	4.0	1.97	32.84	1.97	0.96355
2.0	3.7	-1.71	85.37	1.71	0.78636
5.0	6.4	-1.36	27.13	1.36	0.28954
8.0	6.2	1.77	22.17	1.77	0.50521
9.0	8.1	0.86	9.60	0.86	0.09171
7.0	6.2	0.84	12.05	0.84	0.11561
9.0	7.2	1.78	19.81	1.78	0.44036
3.0	6.6	-3.63	120.88	3.63	1.98460
8.0	6.9	1.15	14.32	1.15	0.19158
4.0	6.2	-2.17	54.34	2.17	0.76522
6.0	6.6	-0.56	9.25	0.56	0.04700
9.0	5.0	3.97	44.16	3.97	3.14275
7.0	5.9	1.12	16.05	1.12	0.21492
7.0	5.9	1.14	16.34	1.14	0.22350
7.0	4.9	2.09	29.81	2.09	0.88648
8.0	7.6	0.40	5.00	0.40	0.02106
7.0	6.3	0.74	10.52	0.74	0.08655
8.0	7.3	0.73	9.10	0.73	0.07282
8.0	8.0	0.01	0.14	0.01	0.00002
7.0	6.9	0.11	1.56	0.11	0.00172
			MAPE	**MAD**	**Total**
			26.68	**1.37**	**13.41669**

Degree of freedom = 27 - 1 = 26
Tab Chi-square (5%) = 38.885 > Calc Chi-square = 13.417
Pearson Correlation, r = 0.446, p = 0.010 (1-tailed)

Table J6.1 Assessment of the performance of the MR model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square	Predicted w/ constant	Residual	APE %	AD	Chi-square
7.0	7.8	-0.78	11.17	0.78	0.07860	8.1	-1.10	15.73	1.10	0.14966
10.0	9.5	0.54	5.35	0.54	0.03030	9.8	0.22	2.16	0.22	0.00477
7.0	6.3	0.71	10.10	0.71	0.07944	6.6	0.39	5.56	0.39	0.02289
7.0	6.3	0.74	10.64	0.74	0.08860	6.6	0.43	6.09	0.43	0.02763
8.0	6.9	1.14	14.21	1.14	0.18826	7.2	0.82	10.23	0.82	0.09324
5.0	4.4	0.65	12.97	0.65	0.09668	4.7	0.33	6.61	0.33	0.02343
4.0	4.1	-0.14	3.55	0.14	0.00487	4.5	-0.46	11.49	0.46	0.04739
8.0	7.0	1.04	12.98	1.04	0.15484	7.3	0.72	9.00	0.72	0.07122
4.0	4.5	-0.53	13.27	0.53	0.06215	4.8	-0.85	21.22	0.85	0.14855
8.0	6.5	1.47	18.35	1.47	0.32972	6.9	1.15	14.36	1.15	0.19267
8.0	8.7	-0.70	8.79	0.70	0.05686	9.0	-1.02	12.78	1.02	0.11589
9.0	7.2	1.77	19.67	1.77	0.43367	7.5	1.45	16.13	1.45	0.27903
6.0	6.5	-0.50	8.32	0.50	0.03835	6.8	-0.82	13.63	0.82	0.09807
8.0	8.2	-0.19	2.33	0.19	0.00426	8.5	-0.50	6.31	0.50	0.02999
7.0	8.8	-1.77	25.30	1.77	0.35769	9.1	-2.09	29.86	2.09	0.48071
10.0	7.9	2.06	20.56	2.06	0.53219	8.3	1.74	17.37	1.74	0.36510
7.0	7.0	0.00	0.05	0.00	0.00000	7.3	-0.32	4.50	0.32	0.01358
8.0	9.4	-1.38	17.22	1.38	0.20239	9.7	-1.70	21.21	1.70	0.29697
5.0	5.3	-0.29	5.78	0.29	0.01578	5.6	-0.61	12.14	0.61	0.06571
8.0	7.2	0.84	10.48	0.84	0.09818	7.5	0.52	6.50	0.52	0.03617
7.0	6.9	0.07	1.04	0.07	0.00076	7.2	-0.25	3.51	0.25	0.00834
8.0	8.7	-0.66	8.19	0.66	0.04958	9.0	-0.97	12.17	0.97	0.10559
10.0	9.0	1.01	10.07	1.01	0.11267	9.3	0.69	6.87	0.69	0.05066
9.0	8.8	0.25	2.76	0.25	0.00707	9.1	-0.07	0.78	0.07	0.00054
10.0	10.5	-0.47	4.68	0.47	0.02088	10.8	-0.79	7.87	0.79	0.05742
10.0	8.1	1.94	19.37	1.94	0.46512	8.4	1.62	16.18	1.62	0.31212
9.0	8.7	0.32	3.53	0.32	0.01162	9.0	0.00	0.02	0.00	0.00000
7.0	7.1	-0.06	0.93	0.06	0.00060	7.4	-0.38	5.48	0.38	0.01994
7.0	6.2	0.78	11.10	0.78	0.09708	6.5	0.46	6.56	0.46	0.03225
9.0	8.5	0.49	5.42	0.49	0.02794	8.8	0.17	1.87	0.17	0.00321
6.0	6.6	-0.61	10.18	0.61	0.05645	6.9	-0.93	15.48	0.93	0.12455
8.0	7.9	0.07	0.85	0.07	0.00059	8.3	-0.25	3.13	0.25	0.00758
7.0	8.7	-1.68	23.97	1.68	0.32446	9.0	-2.00	28.53	2.00	0.44325
3.0	3.5	-0.49	16.33	0.49	0.06877	3.8	-0.81	26.92	0.81	0.17134
10.0	9.3	0.72	7.20	0.72	0.05578	9.6	0.40	4.00	0.40	0.01664
5.0	5.6	-0.62	12.35	0.62	0.06785	5.9	-0.94	18.73	0.94	0.14770
2.0	2.8	-0.76	37.95	0.76	0.20880	3.1	-1.08	53.82	1.08	0.37662
3.0	4.3	-1.26	41.90	1.26	0.37116	4.6	-1.58	52.55	1.58	0.54301
8.0	7.8	0.24	3.01	0.24	0.00747	8.1	-0.08	0.97	0.08	0.00074
9.0	10.1	-1.14	12.62	1.14	0.12734	10.5	-1.46	16.17	1.46	0.20267
5.0	5.4	-0.37	7.35	0.37	0.02517	5.7	-0.69	13.73	0.69	0.08286
8.0	7.7	0.25	3.15	0.25	0.00818	8.1	-0.07	0.84	0.07	0.00056
3.0	3.6	-0.65	21.65	0.65	0.11555	4.0	-0.97	32.24	0.97	0.23582
6.0	6.0	0.02	0.38	0.02	0.00009	6.3	-0.30	4.93	0.30	0.01391
8.0	8.4	-0.45	5.57	0.45	0.02354	8.8	-0.76	9.56	0.76	0.06677
7.0	7.9	-0.91	13.02	0.91	0.10505	8.2	-1.23	17.59	1.23	0.18410
2.0	2.3	-0.33	16.50	0.33	0.04675	2.6	-0.65	32.41	0.65	0.15862
4.0	3.7	0.28	7.05	0.28	0.02142	4.0	-0.04	0.89	0.04	0.00032
4.0	3.3	0.70	17.48	0.70	0.14811	3.6	0.38	9.53	0.38	0.04018
3.0	3.5	-0.52	17.33	0.52	0.07681	3.8	-0.84	27.90	0.84	0.18263
7.0	7.3	-0.35	4.95	0.35	0.01636	7.7	-0.67	9.50	0.67	0.05774
4.0	4.3	-0.27	6.80	0.27	0.01729	4.6	-0.59	14.73	0.59	0.07560
8.0	6.8	1.17	14.67	1.17	0.20166	7.1	0.85	10.67	0.85	0.10203
8.0	9.4	-1.39	17.39	1.39	0.20609	9.7	-1.71	21.39	1.71	0.30145
			MAPE	**MAD**	**Total**			**MAPE**	**MAD**	**Total**
			11.44	**0.71**	**5.94687**			**13.53**	**0.78**	**6.68938**

Degree of freedom = 54 - 1 = 53

Tab Chi-square (5%) =70.993 > Calc Chi-square = 5.947
Pearson Correlation, r = 0.918, p = 0.000 (1-tailed)

Tab Chi-square (5%) = 70.993 > Calc Chi-square = 6.689
Pearson Correlation, r = 0.918, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table J6.2 Assessment of the validation of the MR model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square
7.0	4.1	2.90	41.44	2.90	2.05264
7.0	8.1	-1.09	15.50	1.09	0.14561
9.0	8.2	0.79	8.79	0.79	0.07622
8.0	8.9	-0.93	11.64	0.93	0.09705
8.0	8.5	-0.54	6.74	0.54	0.03402
9.0	8.8	0.17	1.93	0.17	0.00343
3.0	5.8	-2.83	94.43	2.83	1.37583
7.0	7.4	-0.40	5.74	0.40	0.02180
8.0	5.0	2.99	37.41	2.99	1.78911
1.0	4.1	-3.10	309.94	3.10	2.34333
7.0	8.3	-1.35	19.26	1.35	0.21766
			MAPE	**MAD**	**Total**
			50.26	1.55	8.15669
without outlier (10th case)			**24.29**	**1.40**	**5.81336**

Degree of freedom = 10 - 1 = 9
Tab Chi-square (5%) = 16.919 > Calc Chi-square = 5.813
Pearson Correlation, r = 0.429, p = 0.108 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Appendix K:

Calculations of the Total Sensitivity Factors (TSFs) in the ANN Analysis

Table K1.1 Independent variables in the second stage ANN model of architects' assessment of client performance

Variables	Sensitivity Factor (SF)
PRTPR2	1.6791
CLNAT2	1.0573
PRTBD1	0.9157
PRTBD4	0.8054
PRROU0	0.7973
CLNAT4	0.5871
PRROU2	0.5695
RSSATCL	0.3817
PRBUDOV	0.3465
PRTBD0	0.2828
CLNAT3	0.2595
CLATTPM	0.1756
PRTBD3	0.1725
PRDUROV	0.1610
PRTPR0	0.1354
CLATTQE	0.0784

Table K1.2 Total sensitivity factors for binary dummy variables identified from the architects' assessment of client performance

CLNAT	SF	PRROU	SF	PRTBD	SF	PRTPR	SF
CLNAT2	1.0573	PRROU0	0.7973	PRTBD0	0.2828	PRTPR0	0.1354
CLNAT3	0.2595	PRROU2	0.5695	PRTBD1	0.9157	PRTPR2	1.6791
CLNAT4	0.5871			PRTBD3	0.1725		
				PRTBD4	0.8054		
Average	0.6346		0.6834		0.5441		0.9073

Table K1.3 Total sensitive factors (TSFs) for independent variables identified from the architects' assessment of client performance

Attributes	Total sensitivity factor	Ranking
PRTPR	0.9073	1
PRROU	0.6834	2
CLNAT	0.6346	3
PRTBD	0.5441	4
RSSATCL	0.3817	5
PRBUDOV	0.3465	6
CLATTPM	0.1756	7
PRDUROV	0.1610	8
CLATTQE	0.0784	9

Table K2.1 Independent variables in the second stage ANN model of contractors' assessment of client performance

Variable	Sensitivity Factor (SF)
PRDUROV	0.6668
PRBUDMO	0.5786
PRTBD0	0.4918
PRROU2	0.4743
PRTPR2	0.4282
CLNAT4	0.4079
CLNAT2	0.4078
PRTBD4	0.3074
PRTBD1	0.3000
PRBUDOV	0.2781
CLATTQE	0.2380
CLNAT0	0.2139
CLNAT1	0.1783
RSSATCL	0.1346
PRROU0	0.1209
CLNAT3	0.1141
PRTPR0	0.1059
PRTBD2	0.0894

Table K2.2 Total sensitivity factors for binary dummy variables identified from the contractors' assessment of client performance

CLNAT	SF	PRROU	SF	PRTBD	SF	PRTPR	SF
CLNAT0	0.2139	PRROU0	0.1209	PRTBD0	0.4918	PRTPR0	0.1059
CLNAT1	0.1783	PRROU2	0.4743	PRTBD1	0.3000	PRTPR2	0.4282
CLNAT2	0.4078			PRTBD2	0.0894		
CLNAT3	0.1141			PRTBD4	0.3074		
CLNAT4	0.4079						
Average	0.2644		0.2976		0.2972		0.2671

Table K2.3 Total sensitive factors (TSFs) for independent variables identified from the contractors' assessment of client performance

Attributes	Total sensitivity factor	Ranking
PRDUROV	0.6668	1
PRBUDMO	0.5786	2
PRROU	0.2976	3
PRTBD	0.2972	4
PRBUDOV	0.2781	5
PRTPR	0.2671	6
CLNAT	0.2644	7
CLATTQE	0.2380	8
RSSATCL	0.1346	9

Table K3.1 Independent variables in the second stage ANN model of clients' assessment of architect performance

Variable	Sensitivity Factor (SF)
RSSATAR	0.0950
RSARC4	0.0849
RSARC6	0.0142
PRTPR0	0.1000
PRTPR1	0.2063
PRROU0	0.0313
PRROU2	0.1227
PRDUROV	0.7903
PRBUDOV	0.2688
PRVARSE	0.1419
AREMP	0.2032
ARPERCL	0.2440
ARATTBU	0.0483
ARATTQU	0.0479
ARATTSP	0.0585

Table K3.2 Total sensitivity factors for binary dummy variables identified from the clients' assessment of architect performance

PRROU	SF	PRTPR	SF
PRROU0	0.0313	PRTPR0	0.1000
PRROU2	0.1227	PRTPR1	0.2063
Average	0.0770		0.1532

Table K3.3 Total sensitive factors (TSFs) for independent variables identified from the clients' assessment of architect performance

Attributes	Total sensitivity factor	Ranking
PRDUROV	0.7903	1
PRBUDOV	0.2688	2
ARPERCL	0.2440	3
AREMP	0.2032	4
PRTPR	0.1532	5
PRVARSE	0.1419	6
RSSATAR	0.0950	7
RSARC4	0.0849	8
PRROU	0.0770	9
ARATTSP	0.0585	10
ARATTBU	0.0483	11
ARATTQU	0.0479	12
RSARC6	0.0142	13

Table K4.1 Independent variables in the second stage ANN model of contractors' assessment of architect performance

Variable	Sensitivity Factor (SF)
PRTPR0	0.1976
PRTPR2	0.3682
PRROU0	0.8772
PRROU1	1.0802
PRROU2	0.7982
PRDUROV	0.4595
PRBUDMO	0.1188
PRVARAR	0.1873
ARWL	0.0884
ARPERCO	0.5377
ARATTPP	0.1786
ARATTSC	0.2710
ARATTDI	0.0210
ARATTSP	0.2170

Table K4.2 Total sensitivity factors for binary dummy variables identified from the contractors' assessment of architect performance

PRROU	SF	PRTPR	SF
PRROU0	0.8772	PRTPR0	0.1976
PRROU1	1.0802	PRTPR2	0.3682
PRROU2	0.7982		
Average	0.9185		0.2829

Table K4.3 Total sensitive factors (TSFs) for independent variables identified from the contractors' assessment of architect performance

Attributes	Total sensitivity factor	Ranking
PRROU	0.9185	1
ARPERCO	0.5377	2
PRDUROV	0.4595	3
PRTPR	0.2829	4
ARATTSC	0.2710	5
ARATTSP	0.2170	6
PRVARAR	0.1873	7
ARATTPP	0.1786	8
PRBUDMO	0.1188	9
ARWL	0.0884	10
ARATTDI	0.0210	11

Table K5.1 Independent variables in the second stage ANN model of clients' assessment of contractor performance

Variable	Sensitivity Factor (SF)
PRTPR0	0.1580
PRTPR1	0.0091
PRTBD0	0.1822
PRTBD1	0.3020
PRTBD2	0.0426
PRTBD3	0.3269
PRTBD4	0.7648
PRROU0	0.3647
PRROU1	0.2065
PRROU2	0.3864
PRDUROV	0.6876
PRBUDOV	0.1558
PRVARCO	0.2357
COSELCO0	0.4250
COSELCO1	0.1324
COSELCO2	0.7530
COWL	0.0601
COPAYCO0	0.2635
COPAYCO1	0.2934
COPAYCO2	0.2383
COPERCL	0.6203
COATTQU	0.2775

Table K5.2 Total sensitivity factors for binary dummy variables identified from the clients' assessment of contractor performance

COSELCO	SF	COPAYCO	SF	PRROU	SF	PRTBD	SF	PRTPR	SF
COSELCO0	0.4250	COPAYCO0	0.2635	PRROU0	0.3647	PRTBD0	0.1822	PRTPR0	0.1580
COSELCO1	0.1324	COPAYCO1	0.2934	PRROU1	0.2065	PRTBD1	0.3020	PRTPR1	0.0091
COSELCO2	0.7530	COPAYCO2	0.2383	PRROU2	0.3864	PRTBD2	0.0426		
						PRTBD3	0.3269		
						PRTBD4	0.7648		
Average	0.4368		0.2651		0.3192		0.3237		0.0835

Table K5.3 Total sensitive factors (TSFs) for independent variables identified from the clients' assessment of contractor performance

Attributes	Total sensitivity factor	Ranking
PRDUROV	0.6876	1
COPERCL	0.6203	2
COSELCO	0.4368	3
PRTBD	0.3237	4
PRROU	0.3192	5
COATTQU	0.2775	6
COPAYCO	0.2651	7
PRVARCO	0.2357	8
PRBUDOV	0.1558	9
PRTPR	0.0835	10
COWL	0.0601	11

Table K6.1 Independent variables in the second stage ANN model of architects' assessment of contractor performance

Variable	Sensitivity Factor (SF)
COSELCO1	1.8059
PRBUDOV	1.5046
PRTPR2	1.4204
COSELCO0	1.3826
PRTBD1	1.3591
PRROU2	1.3378
COSELCO2	1.2313
PRTBD0	1.1849
PRTBD3	0.7068
PRDUROV	0.6543
PRTBD2	0.6085
RSSATCO	0.5491
COPAYCO1	0.4739
PRROU1	0.4391
COPAYCO2	0.3699
COATTDI	0.3071
PRTPR1	0.2688
PRTBD4	0.2561
PRROU0	0.2526
COATTFI	0.1807
COPAYCO0	0.1692
COPERAR	0.0813
COATTTY	0.0671
PRVARSE	0.0299

Table K6.2 Total sensitivity factors for binary dummy variables identified from the architects' assessment of contractor performance

COSELCO	SF	COPAYCO	SF	PRROU	SF	PRTBD	SF	PRTPR	SF
COSELCO0	1.3826	COPAYCO0	0.1692	PRROU0	0.2526	PRTBD0	1.1849	PRTPR1	0.2688
COSELCO1	1.8059	COPAYCO1	0.4739	PRROU1	0.4391	PRTBD1	1.3591	PRTPR2	1.4204
COSELCO2	1.2313	COPAYCO2	0.3699	PRROU2	1.3378	PRTBD2	0.6085		
						PRTBD3	0.7068		
						PRTBD4	0.2561		
Average	1.4733		0.3376		0.6765		0.8231		0.8446

Table K6.3 Total sensitive factors (TSFs) for independent variables identified from the architects' assessment of contractor performance

Attributes	Total sensitivity factor	Ranking
PRBUDOV	1.5046	1
COSELCO	1.4733	2
PRTPR	0.8446	3
PRTBD	0.8231	4
PRROU	0.6765	5
PRDUROV	0.6543	6
RSSATCO	0.5491	7
COPAYCO	0.3376	8
COATTDI	0.3071	9
COATTFI	0.1807	10
COPERAR	0.0813	11
COATTTY	0.0671	12
PRVARSE	0.0299	13

Appendix L:

Assessment of the Performance and Validation of the ANN Models

Appendix L1: Assessment of the performance and validation of the ANN model based on architects' assessment of client performance

Appendix L2: Assessment of the performance and validation of the ANN model based on contractors' assessment of client performance

Appendix L3: Assessment of the performance and validation of the ANN model based on clients' assessment of architect performance

Appendix L4: Assessment of the performance and validation of the ANN model based on contractors' assessment of architect performance

Appendix L5: Assessment of the performance and validation of the ANN model based on clients' assessment of contractor performance

Appendix L6: Assessment of the performance and validation of the ANN model based on architects' assessment of contractor performance

Table L1.1 Assessment of the performance of the ANN model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square
7.0	7.2	-0.20	2.93	0.20	0.00583
8.0	8.0	-0.04	0.51	0.04	0.00020
9.0	9.3	-0.32	3.51	0.32	0.01070
9.0	8.5	0.45	5.01	0.45	0.02374
9.0	9.3	-0.31	3.45	0.31	0.01033
3.0	3.5	-0.55	18.25	0.55	0.08454
6.0	6.1	-0.13	2.19	0.13	0.00282
9.0	8.8	0.21	2.31	0.21	0.00492
6.0	5.7	0.33	5.58	0.33	0.01978
9.0	9.4	-0.42	4.68	0.42	0.01885
6.0	7.8	-1.81	30.20	1.81	0.42023
9.0	8.5	0.50	5.61	0.50	0.02999
8.0	8.2	-0.15	1.92	0.15	0.00289
10.0	9.8	0.19	1.93	0.19	0.00379
6.0	5.9	0.10	1.64	0.10	0.00165
8.0	8.3	-0.30	3.74	0.30	0.01080
8.0	8.4	-0.41	5.17	0.41	0.02033
5.0	5.8	-0.80	16.02	0.80	0.11055
10.0	9.1	0.89	8.88	0.89	0.08646
9.0	7.7	1.29	14.37	1.29	0.21693
7.0	6.8	0.17	2.39	0.17	0.00408
6.0	5.8	0.16	2.59	0.16	0.00412
5.0	4.7	0.25	5.09	0.25	0.01362
8.0	7.8	0.19	2.32	0.19	0.00439
6.0	6.3	-0.26	4.41	0.26	0.01116
8.0	8.4	-0.37	4.60	0.37	0.01617
9.0	8.9	0.14	1.60	0.14	0.00233
10.0	9.7	0.33	3.31	0.33	0.01134
9.0	9.2	-0.24	2.67	0.24	0.00627
9.0	8.5	0.51	5.71	0.51	0.03115
5.0	5.1	-0.15	2.91	0.15	0.00410
9.0	9.0	-0.01	0.10	0.01	0.00001
9.0	8.6	0.38	4.17	0.38	0.01631
7.0	6.7	0.29	4.14	0.29	0.01253
7.0	6.8	0.15	2.20	0.15	0.00346
9.0	9.4	-0.40	4.44	0.40	0.01699
9.0	8.6	0.36	3.96	0.36	0.01473
10.0	9.5	0.49	4.89	0.49	0.02517
8.0	7.9	0.13	1.56	0.13	0.00199
7.0	7.2	-0.19	2.76	0.19	0.00519
4.0	5.0	-0.96	24.06	0.96	0.18671
7.0	7.1	-0.15	2.11	0.15	0.00305
9.0	9.2	-0.16	1.79	0.16	0.00282
4.0	4.6	-0.60	15.11	0.60	0.07937
9.0	8.4	0.61	6.74	0.61	0.04384
7.0	6.5	0.46	6.51	0.46	0.03169
6.0	6.1	-0.11	1.79	0.11	0.00189
8.0	7.9	0.10	1.20	0.10	0.00117
10.0	9.5	0.51	5.09	0.51	0.02733
4.0	4.1	-0.05	1.36	0.05	0.00073
8.0	7.6	0.39	4.87	0.39	0.01996
7.0	7.1	-0.06	0.86	0.06	0.00051
3.0	3.9	-0.87	29.09	0.87	0.19663
9.0	9.1	-0.07	0.83	0.07	0.00062
			MAPE	MAD	Total
			5.65	0.36	1.88679

Degree of freedom = 54 - 1 = 53
Tab Chi-square (5%) = 70.993 > Calc Chi-square = 1.887
Pearson Correlation, r = 0.967, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table L1.2 Assessment of the validation of the ANN model for *totsat*

Actual x	Predicted p	Residual $x-p$	APE %	AD	Chi-square
6.0	8.5	-2.50	41.65	2.50	0.73488
5.0	7.0	-1.97	39.40	1.97	0.55672
5.0	6.4	-1.43	28.61	1.43	0.31820
6.0	7.8	-1.81	30.17	1.81	0.41952
8.0	6.6	1.37	17.16	1.37	0.28422
4.0	5.1	-1.05	26.31	1.05	0.21915
8.0	9.6	-1.57	19.62	1.57	0.25750
9.0	9.6	-0.58	6.47	0.58	0.03534
3.0	3.3	-0.30	9.91	0.30	0.02682
10.0	7.9	2.07	20.74	2.07	0.54299
9.0	8.8	0.20	2.19	0.20	0.00443
7.0	7.3	-0.32	4.57	0.32	0.01398
4.0	5.4	-1.39	34.74	1.39	0.35837
7.0	7.8	-0.79	11.31	0.79	0.08040
7.0	7.0	0.00	0.06	0.00	0.00000
			MAPE	**MAD**	**Total**
			19.53	**1.16**	**3.85253**

Degree of freedom = 15 - 1 = 14
Tab Chi-square (5%) = 23.685 > Calc Chi-square = 3.853
Pearson Correlation, r = 0.796, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table L2.1 Assessment of the performance of the ANN model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square
3.0	3.2	-0.17	5.61	0.17	0.00895
7.0	7.0	0.00	0.01	0.00	0.00000
5.0	5.5	-0.47	9.36	0.47	0.04004
10.0	9.8	0.17	1.73	0.17	0.00306
7.0	7.0	-0.04	0.57	0.04	0.00023
6.0	5.7	0.32	5.29	0.32	0.01771
9.0	9.7	-0.66	7.35	0.66	0.04529
9.0	8.9	0.10	1.12	0.10	0.00113
8.0	8.6	-0.56	6.96	0.56	0.03624
9.0	9.8	-0.81	9.02	0.81	0.06723
9.0	8.6	0.44	4.92	0.44	0.02295
8.0	7.8	0.24	3.02	0.24	0.00753
4.0	4.1	-0.09	2.29	0.09	0.00205
7.0	7.1	-0.05	0.78	0.05	0.00042
9.0	9.0	0.01	0.11	0.01	0.00001
9.0	8.7	0.31	3.49	0.31	0.01137
8.0	8.0	-0.02	0.25	0.02	0.00005
9.0	9.0	0.02	0.17	0.02	0.00003
7.0	6.6	0.36	5.09	0.36	0.01910
9.0	8.2	0.81	9.01	0.81	0.08037
3.0	2.8	0.23	7.67	0.23	0.01910
8.0	5.8	2.21	27.65	2.21	0.84563
9.0	9.2	-0.16	1.81	0.16	0.00290
9.0	8.3	0.71	7.85	0.71	0.06016
5.0	6.0	-1.01	20.23	1.01	0.17022
9.0	8.6	0.40	4.40	0.40	0.01819
7.0	7.0	0.04	0.51	0.04	0.00018
10.0	9.5	0.52	5.18	0.52	0.02834
6.0	6.3	-0.32	5.31	0.32	0.01605
7.0	6.8	0.25	3.52	0.25	0.00897
1.0	1.9	-0.93	92.94	0.93	0.44770
8.0	7.5	0.48	5.95	0.48	0.03011
9.0	8.9	0.06	0.70	0.06	0.00045
7.0	6.9	0.13	1.80	0.13	0.00231
6.0	6.2	-0.18	3.06	0.18	0.00546
7.0	6.9	0.10	1.46	0.10	0.00151
3.0	3.7	-0.68	22.63	0.68	0.12533
8.0	8.8	-0.78	9.78	0.78	0.06973
8.0	9.6	-1.57	19.58	1.57	0.25638
10.0	9.5	0.47	4.74	0.47	0.02362
8.0	9.0	-0.96	12.00	0.96	0.10288
7.0	7.0	-0.03	0.47	0.03	0.00015
10.0	9.4	0.59	5.87	0.59	0.03657
2.0	2.6	-0.57	28.61	0.57	0.12729
6.0	6.3	-0.29	4.88	0.29	0.01365
1.0	2.5	-1.51	150.66	1.51	0.90551
10.0	9.6	0.37	3.66	0.37	0.01389
3.0	3.6	-0.63	21.02	0.63	0.10953
2.0	1.2	0.76	38.23	0.76	0.47308
8.0	7.8	0.24	3.00	0.24	0.00744
7.0	7.9	-0.90	12.90	0.90	0.10319
9.0	8.8	0.15	1.71	0.15	0.00269
9.0	9.5	-0.51	5.65	0.51	0.02724
10.0	9.4	0.60	5.99	0.60	0.03818
9.0	8.5	0.47	5.20	0.47	0.02572
			MAPE	MAD	Total
			11.32	0.46	4.48311

Degree of freedom = 55 - 1 = 54
Tab Chi-square (5%) = 72.153 > Calc Chi-square = 4.483
Pearson Correlation, r = 0.967, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table L2.2 Assessment of the validation of the ANN model for *totsat*

Actual x	Predicted p	Residual $x-p$	APE %	AD	Chi-square
7.0	6.8	0.18	2.52	0.18	0.00455
9.0	9.1	-0.09	0.95	0.09	0.00081
6.0	8.7	-2.71	45.11	2.71	0.84136
8.0	8.2	-0.23	2.88	0.23	0.00644
8.0	8.6	-0.61	7.61	0.61	0.04305
4.0	2.8	1.17	29.30	1.17	0.48551
10.0	8.0	2.00	20.04	2.00	0.50234
5.0	6.2	-1.21	24.24	1.21	0.23642
2.0	5.6	-3.58	178.99	3.58	2.29659
6.0	4.2	1.79	29.86	1.79	0.76261
10.0	9.6	0.39	3.89	0.39	0.01576
5.0	7.5	-2.53	50.60	2.53	0.84998
8.0	9.0	-1.01	12.65	1.01	0.11357
8.0	9.4	-1.37	17.11	1.37	0.20008
8.0	9.2	-1.17	14.68	1.17	0.15030
6.0	4.7	1.29	21.44	1.29	0.35112
3.0	6.6	-3.62	120.54	3.62	1.97648
6.0	8.3	-2.28	37.96	2.28	0.62660
9.0	7.7	1.28	14.18	1.28	0.21089
4.0	3.1	0.88	22.03	0.88	0.24909
8.0	6.3	1.66	20.69	1.66	0.43203
5.0	6.4	-1.41	28.18	1.41	0.30984
6.0	7.9	-1.92	31.94	1.92	0.46405
7.0	5.8	1.22	17.48	1.22	0.25914
6.0	5.6	0.40	6.70	0.40	0.02889
			MAPE	MAD	Total
			30.46	1.44	11.41749

Degree of freedom = 25 - 1 = 24
Tab Chi-square (5%) = 36.415 > Calc Chi-square = 11.417
Pearson Correlation, r = 0.646, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table L3.1 Assessment of the performance of the ANN model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square
5.0	4.4	0.61	12.14	0.61	0.08393
4.0	4.0	-0.04	1.11	0.04	0.00048
2.0	2.5	-0.46	23.22	0.46	0.08748
8.0	8.0	0.02	0.27	0.02	0.00006
7.0	7.2	-0.19	2.69	0.19	0.00493
8.0	8.7	-0.73	9.17	0.73	0.06164
9.0	8.6	0.42	4.72	0.42	0.02104
9.0	8.7	0.34	3.76	0.34	0.01322
8.0	8.9	-0.86	10.75	0.86	0.08344
3.0	3.9	-0.89	29.72	0.89	0.20422
9.0	8.7	0.26	2.90	0.26	0.00778
9.0	8.8	0.20	2.20	0.20	0.00443
7.0	7.1	-0.07	0.97	0.07	0.00066
9.0	8.9	0.09	1.05	0.09	0.00100
7.0	7.1	-0.14	1.99	0.14	0.00271
8.0	8.2	-0.15	1.88	0.15	0.00279
8.0	8.8	-0.80	9.95	0.80	0.07203
8.0	7.6	0.44	5.56	0.44	0.02619
8.0	8.1	-0.09	1.16	0.09	0.00106
9.0	8.9	0.14	1.59	0.14	0.00232
9.0	8.2	0.77	8.58	0.77	0.07246
6.0	6.2	-0.24	4.03	0.24	0.00936
8.0	8.5	-0.47	5.90	0.47	0.02628
8.0	8.5	-0.53	6.58	0.53	0.03246
9.0	8.6	0.38	4.23	0.38	0.01679
8.0	7.6	0.35	4.40	0.35	0.01620
5.0	5.1	-0.11	2.17	0.11	0.00231
9.0	8.7	0.27	3.01	0.27	0.00841
8.0	7.9	0.05	0.67	0.05	0.00036
9.0	8.8	0.16	1.80	0.16	0.00296
9.0	8.2	0.80	8.91	0.80	0.07837
7.0	7.9	-0.89	12.70	0.89	0.10011
7.0	7.0	0.01	0.21	0.01	0.00003
9.0	8.9	0.12	1.36	0.12	0.00168
9.0	8.8	0.15	1.72	0.15	0.00272
9.0	8.7	0.30	3.33	0.30	0.01030
7.0	8.2	-1.22	17.40	1.22	0.18047
3.0	3.5	-0.48	15.87	0.48	0.06518
7.0	7.1	-0.12	1.69	0.12	0.00197
9.0	8.7	0.28	3.06	0.28	0.00871
8.0	8.4	-0.44	5.46	0.44	0.02260
8.0	6.7	1.27	15.81	1.27	0.23766
6.0	6.0	0.03	0.50	0.03	0.00015
7.0	7.0	-0.01	0.19	0.01	0.00003
8.0	7.7	0.28	3.50	0.28	0.01017
9.0	8.2	0.77	8.60	0.77	0.07287
7.0	7.2	-0.18	2.63	0.18	0.00471
2.0	2.4	-0.38	19.01	0.38	0.06074
			MAPE	**MAD**	**Total**
			6.04	**0.38**	**1.72748**

Degree of freedom = 48 - 1 = 47
Tab Chi-square (5%) = 64.001 > Calc Chi-square = 1.727
Pearson Correlation, r = 0.966, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table L3.2 Assessment of the validation of the ANN model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square
8.0	6.6	1.38	17.26	1.38	0.28804
9.0	8.6	0.42	4.65	0.42	0.02038
6.0	5.9	0.13	2.22	0.13	0.00303
8.0	8.0	0.05	0.60	0.05	0.00029
8.0	7.9	0.12	1.54	0.12	0.00192
8.0	8.5	-0.50	6.21	0.50	0.02909
6.0	5.9	0.14	2.26	0.14	0.00313
10.0	8.5	1.50	14.99	1.50	0.26432
3.0	3.0	-0.04	1.30	0.04	0.00050
8.0	3.8	4.16	51.94	4.16	4.49013
5.0	3.5	1.50	29.99	1.50	0.64249
7.0	6.7	0.33	4.70	0.33	0.01623
9.0	8.2	0.80	8.89	0.80	0.07805
8.0	6.1	1.90	23.72	1.90	0.58995
8.0	7.3	0.73	9.13	0.73	0.07344
7.0	4.6	2.44	34.85	2.44	1.30505
8.0	8.4	-0.35	4.40	0.35	0.01486
8.0	8.1	-0.09	1.10	0.09	0.00095
5.0	8.6	-3.64	72.79	3.64	1.53322
5.0	8.8	-3.78	75.54	3.78	1.62541
9.0	8.7	0.29	3.19	0.29	0.00944
			MAPE	MAD	Total
			17.68	1.16	10.98992

Degree of freedom = 21 - 1 = 20
Tab Chi-square (5%) = 31.410 > Calc Chi-square = 10.990
Pearson Correlation, r = 0.532, p = 0.007 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table L4.1 Assessment of the performance of the ANN model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square
6.0	5.5	0.50	8.36	0.50	0.04572
5.0	4.7	0.26	5.14	0.26	0.01394
7.0	7.4	-0.38	5.41	0.38	0.01942
8.0	8.6	-0.60	7.52	0.60	0.04206
9.0	9.6	-0.64	7.09	0.64	0.04227
3.0	3.6	-0.58	19.42	0.58	0.09479
9.0	9.3	-0.35	3.88	0.35	0.01302
10.0	9.5	0.46	4.64	0.46	0.02261
8.0	8.4	-0.38	4.81	0.38	0.01762
9.0	9.4	-0.43	4.77	0.43	0.01957
8.0	7.7	0.34	4.24	0.34	0.01500
7.0	7.2	-0.16	2.28	0.16	0.00356
6.0	6.4	-0.37	6.13	0.37	0.02127
8.0	7.7	0.28	3.45	0.28	0.00989
9.0	8.4	0.60	6.66	0.60	0.04282
9.0	8.3	0.71	7.84	0.71	0.06000
8.0	8.5	-0.46	5.69	0.46	0.02453
8.0	8.3	-0.28	3.44	0.28	0.00918
9.0	8.5	0.46	5.07	0.46	0.02433
6.0	6.7	-0.72	12.04	0.72	0.07758
9.0	9.1	-0.10	1.13	0.10	0.00114
3.0	3.7	-0.66	22.13	0.66	0.12032
5.0	5.2	-0.23	4.66	0.23	0.01036
7.0	6.9	0.15	2.11	0.15	0.00318
2.0	3.5	-1.49	74.75	1.49	0.63944
7.0	7.2	-0.23	3.22	0.23	0.00705
8.0	6.1	1.90	23.73	1.90	0.59055
2.0	1.5	0.47	23.44	0.47	0.14350
4.0	4.5	-0.45	11.30	0.45	0.04586
3.0	2.4	0.63	21.06	0.63	0.16853
2.0	2.0	0.04	1.83	0.04	0.00069
4.0	3.6	0.43	10.67	0.43	0.05099
8.0	8.1	-0.10	1.21	0.10	0.00115
8.0	8.1	-0.12	1.50	0.12	0.00178
9.0	8.5	0.45	5.01	0.45	0.02381
8.0	8.0	0.00	0.00	0.00	0.00000
9.0	8.4	0.60	6.64	0.60	0.04247
1.0	1.6	-0.65	64.60	0.65	0.25352
6.0	5.2	0.80	13.28	0.80	0.12194
2.0	2.7	-0.74	37.07	0.74	0.20048
9.0	7.8	1.24	13.81	1.24	0.19927
7.0	7.7	-0.68	9.65	0.68	0.05939
3.0	3.0	-0.05	1.50	0.05	0.00067
9.0	8.9	0.10	1.15	0.10	0.00121
7.0	8.2	-1.23	17.61	1.23	0.18454
7.0	6.1	0.93	13.31	0.93	0.14316
9.0	8.9	0.15	1.65	0.15	0.00248
8.0	8.2	-0.15	1.92	0.15	0.00289
4.0	4.9	-0.92	22.99	0.92	0.17194
5.0	4.2	0.80	16.01	0.80	0.15253
8.0	8.0	-0.04	0.53	0.04	0.00023
9.0	9.4	-0.39	4.28	0.39	0.01584
9.0	8.1	0.87	9.68	0.87	0.09345
4.0	3.8	0.16	3.99	0.16	0.00662
5.0	6.1	-1.09	21.85	1.09	0.19591
			MAPE	MAD	Total
			10.86	0.51	4.27606

Degree of freedom = 55 - 1 = 54
Tab Chi-square (5%) = 72.153 > Calc Chi-square = 4.276
Pearson Correlation, r = 0.965, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table L4.2 Assessment of the validation of the ANN model for *totsat*

Actual x	Predicted p	Residual $x\text{-}p$	APE %	AD	Chi-square
3.0	5.1	-2.11	70.33	2.11	0.87126
4.0	4.1	-0.11	2.64	0.11	0.00271
4.0	6.0	-2.03	50.79	2.03	0.68429
4.0	3.8	0.17	4.25	0.17	0.00755
10.0	9.4	0.62	6.20	0.62	0.04093
6.0	4.1	1.87	31.12	1.87	0.84331
8.0	7.1	0.86	10.76	0.86	0.10372
7.0	7.2	-0.17	2.38	0.17	0.00387
8.0	8.7	-0.70	8.74	0.70	0.05619
4.0	5.2	-1.19	29.67	1.19	0.27150
3.0	2.9	0.13	4.29	0.13	0.00577
0.0	4.0	-4.02		4.02	4.02472
6.0	5.8	0.21	3.51	0.21	0.00767
3.0	3.1	-0.07	2.24	0.07	0.00147
5.0	6.4	-1.39	27.88	1.39	0.30397
7.0	8.0	-1.00	14.28	1.00	0.12497
7.0	5.2	1.76	25.16	1.76	0.59221
7.0	7.4	-0.36	5.13	0.36	0.01751
			MAPE	**MAD**	**Total**
			17.61	**1.04**	**7.96361**

Degree of freedom = 18 - 1 = 17
Tab Chi-square (5%) = 27.587 > Calc Chi-square = 7.964
Pearson Correlation, r = 0.809, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table L5.1 Assessment of the performance of the ANN model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square
9.0	8.4	0.61	6.74	0.61	0.04385
8.0	8.0	0.04	0.46	0.04	0.00017
8.0	7.8	0.17	2.08	0.17	0.00354
8.0	8.9	-0.86	10.74	0.86	0.08336
3.0	4.1	-1.11	37.11	1.11	0.30131
7.0	7.1	-0.07	0.96	0.07	0.00064
8.0	7.9	0.08	1.03	0.08	0.00086
9.0	8.5	0.52	5.83	0.52	0.03249
10.0	8.8	1.24	12.35	1.24	0.17413
9.0	9.2	-0.17	1.86	0.17	0.00306
8.0	8.4	-0.41	5.15	0.41	0.02017
7.0	7.3	-0.25	3.61	0.25	0.00879
9.0	8.7	0.28	3.06	0.28	0.00869
3.0	3.5	-0.45	15.03	0.45	0.05894
8.0	8.4	-0.36	4.52	0.36	0.01561
9.0	8.7	0.31	3.50	0.31	0.01139
7.0	7.2	-0.24	3.41	0.24	0.00789
10.0	9.3	0.67	6.74	0.67	0.04865
6.0	6.4	-0.41	6.77	0.41	0.02576
7.0	6.8	0.18	2.53	0.18	0.00460
6.0	5.9	0.09	1.47	0.09	0.00131
8.0	7.3	0.68	8.45	0.68	0.06236
6.0	5.5	0.54	9.06	0.54	0.05419
7.0	7.3	-0.27	3.89	0.27	0.01019
9.0	8.8	0.23	2.52	0.23	0.00588
9.0	8.9	0.12	1.36	0.12	0.00169
8.0	8.6	-0.57	7.11	0.57	0.03771
8.0	8.2	-0.18	2.21	0.18	0.00383
9.0	9.4	-0.39	4.30	0.39	0.01592
8.0	8.0	0.00	0.06	0.00	0.00000
7.0	7.5	-0.49	6.93	0.49	0.03143
3.0	4.5	-1.48	49.46	1.48	0.49106
8.0	8.1	-0.10	1.31	0.10	0.00135
8.0	8.2	-0.17	2.16	0.17	0.00365
8.0	7.6	0.36	4.46	0.36	0.01666
9.0	8.9	0.11	1.25	0.11	0.00142
8.0	7.9	0.06	0.79	0.06	0.00050
6.0	6.2	-0.16	2.74	0.16	0.00439
5.0	5.2	-0.24	4.86	0.24	0.01124
9.0	8.7	0.30	3.38	0.30	0.01066
8.0	8.1	-0.07	0.90	0.07	0.00065
9.0	9.0	0.04	0.42	0.04	0.00016
9.0	8.4	0.63	7.01	0.63	0.04756
6.0	6.1	-0.11	1.82	0.11	0.00195
6.0	5.7	0.28	4.69	0.28	0.01387
7.0	6.9	0.06	0.83	0.06	0.00048
8.0	9.0	-1.01	12.58	1.01	0.11247
7.0	7.1	-0.06	0.85	0.06	0.00050
7.0	6.6	0.43	6.10	0.43	0.02775
5.0	4.8	0.17	3.32	0.17	0.00571
			MAPE	MAD	Total
			5.80	0.36	1.83044

Degree of freedom = 50 - 1 = 49
Tab Chi-square (5%) = 66.338 > Calc Chi-square = 1.830
Pearson Correlation, r = 0.958, p = 0.000 (1-tailed)

Table L5.2 Assessment of the validation of the ANN model for *totsat*

Actual x	Predicted p	Residual $x-p$	APE %	AD	Chi-square
6.0	6.2	-0.20	3.27	0.20	0.00619
8.0	6.5	1.51	18.85	1.51	0.35047
7.0	6.6	0.40	5.71	0.40	0.02422
4.0	6.0	-1.98	49.40	1.98	0.65328
5.0	6.6	-1.64	32.84	1.64	0.40586
5.0	4.2	0.78	15.60	0.78	0.14414
9.0	6.5	2.52	27.99	2.52	0.97913
6.0	3.6	2.35	39.20	2.35	1.51593
2.0	3.5	-1.51	75.60	1.51	0.65095
5.0	7.8	-2.82	56.41	2.82	1.01725
8.0	6.5	1.55	19.33	1.55	0.37035
9.0	8.9	0.14	1.54	0.14	0.00218
7.0	7.1	-0.10	1.48	0.10	0.00151
9.0	7.7	1.30	14.40	1.30	0.21793
3.0	5.2	-2.15	71.69	2.15	0.89813
8.0	6.8	1.22	15.29	1.22	0.22089
4.0	5.8	-1.81	45.24	1.81	0.56364
6.0	6.2	-0.17	2.85	0.17	0.00475
9.0	8.2	0.84	9.34	0.84	0.08668
7.0	5.1	1.94	27.68	1.94	0.74141
7.0	5.9	1.13	16.20	1.13	0.21914
7.0	5.3	1.71	24.38	1.71	0.55037
8.0	8.7	-0.68	8.52	0.68	0.05356
7.0	7.6	-0.65	9.22	0.65	0.05452
8.0	8.3	-0.32	3.94	0.32	0.01197
8.0	7.0	0.98	12.23	0.98	0.13623
7.0	5.5	1.50	21.49	1.50	0.41187
			MAPE	MAD	Total
			23.32	1.26	10.29253

Degree of freedom = 27 - 1 = 26
Tab Chi-square (5%) = 38.885 > Calc Chi-square = 10.293
Pearson Correlation, r = 0.630, p = 0.000 (1-tailed)

Table L6.1 Assessment of the performance of the ANN model for *totsat*

Actual x	Predicted p	Residual $x-p$	APE %	AD	Chi-square
7.0	6.6	0.40	5.70	0.40	0.02414
10.0	9.4	0.64	6.40	0.64	0.04380
7.0	7.1	-0.11	1.64	0.11	0.00186
7.0	7.3	-0.29	4.08	0.29	0.01118
8.0	7.5	0.47	5.86	0.47	0.02917
5.0	5.8	-0.80	15.93	0.80	0.10951
4.0	3.6	0.45	11.23	0.45	0.05685
8.0	7.7	0.32	4.01	0.32	0.01342
4.0	4.4	-0.41	10.25	0.41	0.03810
8.0	7.8	0.17	2.13	0.17	0.00370
8.0	8.2	-0.19	2.38	0.19	0.00443
9.0	9.0	-0.02	0.21	0.02	0.00004
6.0	6.5	-0.53	8.84	0.53	0.04305
8.0	7.5	0.49	6.08	0.49	0.03147
7.0	6.5	0.53	7.53	0.53	0.04296
10.0	9.1	0.89	8.94	0.89	0.08787
7.0	6.9	0.07	0.94	0.07	0.00063
8.0	8.9	-0.91	11.42	0.91	0.09360
5.0	4.6	0.43	8.60	0.43	0.04048
8.0	7.7	0.30	3.76	0.30	0.01176
7.0	6.2	0.79	11.29	0.79	0.10061
8.0	7.8	0.17	2.08	0.17	0.00353
10.0	9.5	0.50	4.96	0.50	0.02592
9.0	9.6	-0.58	6.44	0.58	0.03509
10.0	9.6	0.36	3.61	0.36	0.01350
10.0	9.1	0.94	9.44	0.94	0.09847
9.0	9.3	-0.28	3.06	0.28	0.00819
7.0	7.4	-0.44	6.24	0.44	0.02564
7.0	7.2	-0.17	2.40	0.17	0.00394
9.0	9.1	-0.12	1.34	0.12	0.00160
6.0	5.8	0.21	3.57	0.21	0.00795
8.0	8.0	0.05	0.59	0.05	0.00028
7.0	7.8	-0.79	11.22	0.79	0.07918
3.0	3.5	-0.46	15.49	0.46	0.06236
10.0	9.3	0.72	7.23	0.72	0.05633
5.0	4.5	0.51	10.22	0.51	0.05813
2.0	4.2	-2.21	110.62	2.21	1.16193
3.0	3.6	-0.58	19.33	0.58	0.09389
8.0	8.0	-0.01	0.18	0.01	0.00003
9.0	9.0	0.04	0.48	0.04	0.00021
5.0	5.0	0.04	0.71	0.04	0.00026
8.0	7.0	0.96	12.03	0.96	0.13170
3.0	3.1	-0.05	1.77	0.05	0.00092
6.0	6.1	-0.13	2.21	0.13	0.00287
8.0	8.4	-0.40	4.98	0.40	0.01894
7.0	7.3	-0.29	4.18	0.29	0.01174
2.0	2.6	-0.61	30.39	0.61	0.14167
4.0	4.2	-0.16	4.08	0.16	0.00640
4.0	3.3	0.75	18.64	0.75	0.17076
3.0	2.9	0.11	3.82	0.11	0.00455
7.0	7.0	0.01	0.17	0.01	0.00002
4.0	3.9	0.11	2.66	0.11	0.00291
8.0	7.5	0.50	6.24	0.50	0.03327
8.0	8.3	-0.34	4.26	0.34	0.01391
			MAPE	MAD	Total
			8.37	0.42	3.06470

Degree of freedom = 54 - 1 = 53
Tab Chi-square (5%) = 70.993 > Calc Chi-square = 3.065
Pearson Correlation, r = 0.969, p = 0.000 (1-tailed)

Note : Tab Chi-square from Fisher and Yates (1938)

Table L6.2 Assessment of the validation of the ANN model for *totsat*

Actual x	Predicted p	Residual x-p	APE %	AD	Chi-square
7.0	5.8	1.19	17.07	1.19	0.24582
7.0	7.8	-0.84	12.01	0.84	0.09014
9.0	8.6	0.43	4.75	0.43	0.02134
8.0	8.8	-0.81	10.15	0.81	0.07477
8.0	5.8	2.17	27.14	2.17	0.80896
9.0	9.6	-0.60	6.65	0.60	0.03730
3.0	4.0	-1.01	33.75	1.01	0.25553
7.0	8.1	-1.09	15.59	1.09	0.14710
8.0	8.4	-0.44	5.47	0.44	0.02269
1.0	4.5	-3.46	346.31	3.46	2.68714
7.0	8.2	-1.20	17.21	1.20	0.17695
			MAPE	**MAD**	**Total**
			45.10	1.20	4.56772
	without outlier (10th case)		**14.98**	**0.98**	**1.88058**

Degree of freedom = 10 - 1 = 9
Tab Chi-square (5%) = 16.919 > Calc Chi-square = 4.568
Pearson Correlation, r = 0.785, p = 0.004 (1-tailed)